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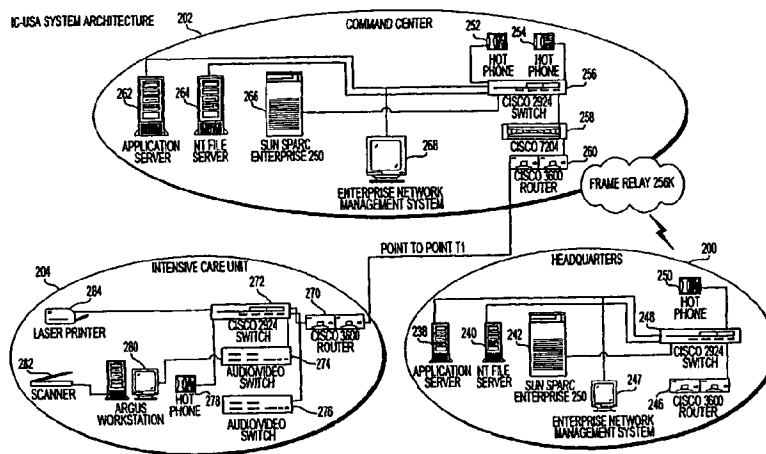
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(54) Title: **SYSTEM AND METHOD FOR PROVIDING CONTINUOUS, EXPERT NETWORK CRITICAL CARE SERVICES FROM A REMOTE LOCATION(S)**



(57) Abstract: A system and method for providing continuous expert network critical care services from a remote location. A plurality of intensive care units (ICU's) with associated patient monitoring instrumentation is connected over a network to a command center which is manned by intensivists 24 hours a day, 7 days a week. The intensivists are prompted to provide critical care by a standardized series of guideline algorithms for treating a variety of critical care conditions. Intensivists monitor the progress of individual patients at remote intensive care units. A smart alarm system provides alarms to the intensivists to alert the intensivists to potential patient problems so that intervention can occur in a timely fashion. A data storage/data warehouse function analyzes individual patient information from a plurality of command centers and provides updated algorithms and critical care support to the command centers.



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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

1       **Title:**           **System and Method for Providing Continuous, Expert Network**  
2                   **Critical Care Services from a Remote Location(s)**

## 6                                   **BACKGROUND OF THE INVENTION**

### 7       **1. Field of the Invention**

8           This invention relates generally to the care of patients in Intensive Care Units  
9 (ICUs). More particularly this invention is a system and method for care of the critically  
10 ill that combines a real-time, multi-node telemedicine network and an integrated,  
11 computerized patient care management system to enable specially-trained Intensivists to  
12 provide 24-hour/7-day-per-week patient monitoring and management to multiple,  
13 geographically dispersed ICUs from both on-site and remote locations.

### 14       **2. Background Art**

15          While the severity of illness of ICU patients over the past 15 years has increased  
16 dramatically, the level of and type of physician coverage in most ICUs has remained  
17 constant. Most ICU patients receive brief minutes of attention during morning rounds  
18 from physicians with limited critical care experience. During the remainder of the day and  
19 night, nurses are the primary caregivers, with specialists called only after patient  
20 conditions have started to deteriorate. The result of this mismatch between severity of  
21 illness and physician coverage is an unacceptably high ICU mortality rate (10%  
22 nationwide), and a high prevalence of avoidable errors that result in clinical complications.

23          In 1998, an Institute of Medicine Roundtable determined that avoidable patient  
24 complications were the single largest problem in medical care delivery. In another  
25 prominent 1998 study of 1000 patients, 46% experienced an avoidable adverse event in  
26 care, with 40% of these errors resulting in serious disability or death.

27          The physicians who can remedy this situation are in critically short supply.  
28 Numerous studies have shown that Intensivists (physicians who have trained and board  
29 certified in Critical Care Medicine) can markedly improve patient outcomes. However,  
30 only one-third of all ICU patients ever has an Intensivist involved in their care, and the  
31 number of Intensivists would need to increase tenfold (nationally) to provide 24-hour

1 coverage to all ICU patients. With the rapid aging of the population, this shortfall of  
2 expertise is going to increase dramatically.

3 Even where Intensivists are present (and especially where they are not), patients  
4 suffer from unnecessary variation in practice. There is little incentive for physicians to  
5 develop and conform to evidence-based best practices (it takes significant work and a  
6 change in behavior to develop and implement them). This variation contributes to sub-  
7 optimal outcomes, in both the quality and cost of care delivered to ICU patients.

8 What is needed is a redesigning of the critical care regimen offered to patients in  
9 an ICU. Rather than the consultative model where a periodic visit takes place and the  
10 doctor then goes away, a more active 24-hour intensivist managed care is required.  
11 Further, technology that leverages the intensivists' expertise and standardizes the care  
12 afforded to patients in an ICU is required. Further, continuous feedback to improve the  
13 practice of intensivists in an ICU is necessary to provide the intervention required to  
14 minimize adverse events. This invention seeks to provide new methods for managing and  
15 delivering care to the critically ill.

16 Attempts to automate various aspects of patient care have been the subject of  
17 various inventions. For example, U.S. Patent No. 5,868,669 to Iliff was issued for  
18 "Computerized Medical Diagnostic and Treatment Advice System." The disclosed  
19 invention is for a system and method for providing computerized knowledge based  
20 medical diagnostic and treatment advice to the general public over a telephone network.

21 U.S. Patent No. 5,823,948 to Ross, Jr. et al was issued for "Medical Records  
22 Documentation, Tracking and Order Entry System". The disclosed invention is for a  
23 system and method that computerizes medical records, documentation, tracking and order  
24 entries. A teleconferencing system is employed to allow patient and medical personnel to  
25 communicate with each other. A video system can be employed to videotape a patient's  
26 consent.

27 U.S. Patent No. 4,878,175 to Norden-Paul et al. was issued for "Method for  
28 Generating Patient-Specific Flowsheets By Adding/Deleting Parameters." The disclosed  
29 invention is for an automated clinical records system for automated entry of bedside  
30 equipment results, such as an EKG monitor, respirator, etc. The system allows for  
31 information to be entered at the bedside using a terminal having input means and a video  
32 display.

1           U.S. Patent No. 5,544,649 to David et al. was issued for "Ambulatory Patient  
2       Health Monitoring Techniques Utilizing Interactive Visual Communications." The  
3       disclosed invention is for an interactive visual system, which allows monitoring of patients  
4       at remote sites, such as the patient's home. Electronic equipment and sensors are used at  
5       the remote site to obtain data from the patient, which is sent to the monitoring site. The  
6       monitoring site can display and save the video, audio and patient's data.

7           U.S. Patent No. 5,867,821 to Ballantyne et al. was issued for "Method and  
8       Apparatus for Electronically Accessing and Distributing Personal Health Care Information  
9       and Services in Hospitals and Homes." The disclosed invention is for an automated  
10      system and method for distribution and administration of medical services, entertainment  
11      services, and electronic health records for health care facilities.

12          U.S. Patent No. 5,832,450 to Myers et al. issued for "Electronic Medical Record  
13      Using Text Database." The disclosed invention is for an electronic medical record system,  
14      which stores data about patient encounters arising from a content generator in freeform  
15      text.

16          U.S. Patent No. 5,812,983 to Kumagai was issued for "Computer Medical File and  
17      Chart System." The disclosed invention is for a system and method which integrates and  
18      displays medical data in which a computer program links a flow sheet of a medical record  
19      to medical charts.

20          U.S. Patent No. 4,489,387 to Lamb et al. was issued for "Method and Apparatus  
21      for Coordinating Medical Procedures." The disclosed invention is for a method and  
22      apparatus that coordinates two or more medical teams to evaluate and treat a patient at the  
23      same time without repeating the same steps.

24          U.S. Patent No. 4,731,725 to Suto et al. issued for "Data Processing System  
25      which Suggests a Pattern of Medical Tests to Reduce the Number of Tests Necessary to  
26      Confirm or Deny a Diagnosis." The disclosed invention is for a data processing system  
27      that uses decision trees for diagnosing a patient's symptoms to confirm or deny the  
28      patient's ailment.

29          U.S. Patent No. 5,255,187 to Sorensen issued for "Computer Aided Medical  
30      Diagnostic Method and Apparatus." The disclosed invention is for an interactive  
31      computerized diagnostic system which relies on color codes which signify the presence or

1 absence of the possibility of a disease based on the symptoms a physician provides the  
2 system.

3 U.S. Patent No. 5,839,438 to Chen et al. issued for "Intelligent Remote Visual  
4 Monitoring System for Home Health Care Service." The disclosed invention is for a  
5 computer-based remote visual monitoring system, which provides in-home patient health  
6 care from a remote location via ordinary telephone lines.

7 U.S. Patent No. 5,842,978 to Levy was issued for "Supplemental Audio Visual  
8 Emergency Reviewing Apparatus and Method." The disclosed invention is for a system  
9 which videotapes a patient and superimposes the patient's vital statistics onto the  
10 videotape.

11 While these invention provide useful records management and diagnostic tool,  
12 none of them provides a comprehensive method for monitoring and providing real time  
13 critical care at disparate ICU's. In short, they are NOT designed for critical care. Further,  
14 none of these inventions provide for the care of a full time intensivist backed by  
15 appropriate database and decision support assistance in the intensive care environment.  
16 What would be useful is a system and method for providing care for the critically ill that  
17 maximizes the presence of an intensivist trained in the care of the critically. Further such  
18 a system would standardize the care in ICU's at a high level and reduce the mortality rate  
19 of patients being cared for in ICU's

## 20 SUMMARY OF THE INVENTION

21 The present invention provides a core business of Continuous Expert Care  
22 Network (CXCN) solution for hospital intensive care units (ICUs). This e-solution uses  
23 network, database, and decision support technologies to provide 24-hour connectivity  
24 between Intensivists and ICUs. The improved access to clinical information and  
25 continuous expert oversight leads to reduced clinical complications, fewer medical errors,  
26 reduced mortality, reduced length of stay, and reduced overall cost per case.

27 The technology of the present invention as explained below can be implemented  
28 all at once or in stages. Thus the technology, as more fully explained below is available in  
29 separate components to allow for the fact that hospitals may not be able to implement all  
30 of the technology at once. Thus modular pieces (e.g. videoconferencing, vital sign  
31 monitoring with smart alarms, hand-held physician productivity tools, etc.) can be  
32 implemented, all of which can add value in a stand-alone capacity. First amongst these

1 offerings will be an Intensivist Decision Support System, a stand-alone software  
2 application that codifies evidence-based, best practice medicine for 150 common ICU  
3 clinical scenarios. These support algorithms are explained more fully below.

4 The "Command Center" model, again as more fully set forth below, will ultimately  
5 give way to a more distributed remote management model where Intensivists and other  
6 physicians can access ICU patients and clinicians (voice, video, data) from their office or  
7 home. In this scenario, the present invention will be available in hospital applications that  
8 centralize ICU information, and offer physicians web-based applications that provide them  
9 with real-time connectivity to this information and to the ICUs. This access and  
10 connectivity will enable physicians to monitor and care for their patients remotely. These  
11 products will be natural extensions and adaptations of the present invention and the  
12 existing applications disclosed herein that those skilled in the art will appreciate and which  
13 do not depart from the scope of the invention as disclosed herein.

14 The present invention addresses these issues and shortcomings of the existing  
15 situation in intensive care, and its shortfalls via two major thrusts. First, an integrated  
16 video/voice/data network application enables continuous real-time management of ICU  
17 patients from a remote setting. Second, a client-server database application B integrated to  
18 the remote care network B provides the data analysis, data presentation, productivity tools  
19 and expert knowledge base that enables a single Intensivist to manage the care of up to 40  
20 patients simultaneously. The combination of these two thrusts B care management from a  
21 remote location and new, technology-enhanced efficiency of Intensivist efforts B allows  
22 health care systems to economically raise the standard of care in their ICUs to one of 24x7  
23 continuous Intensivist oversight.

24 It is therefore an object of the present invention to reduce avoidable complications  
25 in an ICU.

26 It is a further object of the present invention to reduce unexplained variations in  
27 resource utilization in an ICU.

28 It is a further objective of the present invention to mitigate the serious shortage of  
29 intensivists.

30 It is yet another objective of the present invention to reduce the occurrence of  
31 adverse events in an ICU.

1           It is a further objective of the present invention to standardize the care at a high  
2 level among ICUs.

3           It is yet another objective of the present invention to reduce the cost of ICU care.

4           It is yet another objective of the present invention to dramatically decrease the  
5 mortality in an ICU.

6           It is yet another objective of the present invention to bring information from the  
7 ICU to the intensivist, rather than bring the intensivist to the ICU.

8           It is a further objective of the present invention to combine tele-medical systems  
9 comprising two-way audio/video communication with a continuous real time feed of  
10 clinical information to enable the intensivist to oversee care within the ICU.

11           It is a further objective of the present invention to allow intensivists to monitor  
12 ICUs from a site remote from each individual ICU.

13           It is a further objective of the present invention to bring organized detailed clinical  
14 information to the intensivist, thereby providing standardized care in the ICU.

15           It is yet another objective of the present invention to utilize knowledge-based  
16 software to use rules, logic, and expertise to provide preliminary analysis and warnings for  
17 the intensivists.

18           It is a still further objective of the present invention to provide a video visitation  
19 system that allows persons at remote locations using remote terminals to participate in a  
20 video/audio conferencing session with a patient or his/her caregivers local to a patient site.

21           The present invention comprises a command center/remote location, which is  
22 electronically linked to ICUs remote from the command center/remote location. The  
23 command center/remote location is manned by intensivists 24 hours a day, seven days per  
24 week. Each ICU comprises a nurse's station, to which data flows from individual beds in  
25 the ICU. Each patient in the ICU is monitored by a video camera, as well as by clinical  
26 monitors typical for the intensive care unit. These monitors provide constant real time  
27 patient information to the nurse's station, which in turn provides that information over a  
28 dedicated T-1 (high bandwidth) line to the ICU command center/remote location. As  
29 noted earlier, the command center/remote location is remote from the ICU, thereby  
30 allowing the command center/remote location to simultaneously monitor a number of  
31 patients in different ICUs remote from the command center/remote location.



1           At each command center/remote location, video monitors exist so that the  
2           intensivist can visually monitor patients within the ICU. Further, the intensivist can steer  
3           and zoom the video camera near each patient so that specific views of the patient may be  
4           obtained, both up close and generally. Audio links allow intensivists to talk to patients and  
5           staff at an ICU bed location and allow those individuals to converse with the intensivist.

6           Clinical data is constantly monitored and presented to the command center/remote  
7           location in real time so that the intensivist can not only monitor the video of the patient but  
8           also see the vital signs as transmitted from the bedside. The signals from the clinical data  
9           and video data are submitted to a relational database, which comprises 1) standardized  
10          guidelines for the care of the critically ill, 2) various algorithms to support the intensive  
11          care regimen, 3) order writing software so that knowledge-based recommendations and  
12          prescriptions for medication can be made based upon the clinical data, and 4) knowledge-  
13          based vital sign/hemodynamic algorithms that key the intensivist to engage in early  
14          intervention to minimize adverse events.

15          The advantage of the present invention is that intensivists see all patients at a  
16          plurality of ICU's at all times. Further, there is a continuous proactive intensivist care of  
17          all patients within the ICU, thereby minimizing adverse events. Intervention is triggered  
18          by evidence-based data-driven feedback to the intensivist so that standardized care can be  
19          provided across a plurality of ICUs.

20          The economic benefits of the present invention are manifold. For the first time,  
21          24-hour a day, seven day a week intensivist care for patients in an ICU can be obtained.  
22          Further, more timely interventions in the care of the patients can be created by the  
23          knowledge-based guidelines of the present invention, thereby minimizing complications  
24          and adverse events. This in turn will lead to a reduced mortality within the ICU, and  
25          hence, a reduced liability cost due to the dramatic reduction in avoidable errors in health  
26          care.

27          By providing timely interventions, the length of stay within the ICU can be greatly  
28          reduced, thereby allowing more critically ill patients to be cared for in the ICU.

29          In addition, by reviewing and standardizing the care afforded to patients in an ICU,  
30          a more standardized practice across a variety of ICUs can be achieved. This will lead to  
31          more cost-effective care within the ICU, and reduced ancillary cost for the care of the  
32          critically ill.

1           The overall architecture of the present invention comprises a "pod." The pod  
2 comprises a tele-medicine command center/remote location connected to a plurality  
3 multiple ICUs at various locations. The connection between the command center/remote  
4 location and the ICUs is via a dedicated wide-area network linking the ICUs to the  
5 command center/remote location and a team of intensivists who integrate their services to  
6 provide 24-hour, seven day a week care to all of the pod ICUs.

7           The pod is connected via a wide-area network using dedicated T-1 lines, for  
8 example, with redundant backup. This network provides reliable, high speed secure  
9 transmission of clinical data and video/audio signals between each patient room and the  
10 command center/remote location. The use of a T-1 line is not meant as a limitation. It is  
11 expected that more and higher bandwidth networks will become available. Such high  
12 bandwidth networks would come within the scope of the invention as well.

13           Each patient room is equipped with a pan/tilt/zoom video camera with audio and  
14 speaker to enable full videoconferencing capability. In addition, computer workstations  
15 are dedicated for exclusive physician use in each ICU, preferably at the nurse's station.  
16 Intensivists use the workstations to view patient information, consult decision support  
17 information, record their notes, and generate patient orders.

18           The patient management software used by intensivists is provided across the pod.  
19 Updates and changes made to the record are available at both the ICU and the command  
20 center/remote location for any given patient.

21           Each command center/remote location contains at least three workstations: one for  
22 the intensivist, one for the critical care registered nurse, and one for a clerk/administrative  
23 person.

24           The intensivist workstation comprises separate monitors for displaying ICU video  
25 images of patients and/or ICU personnel, output from bedside monitoring equipment,  
26 patient clinical data comprising history, notes, lab reports, etc., and decision support  
27 information. The staff at the command center/remote location are able to activate and  
28 control the cameras in each patient's room so that appropriate visual views of the patient  
29 can be generated.

30           Intensivists are able to switch between rooms and patients and can monitor at least  
31 two rooms simultaneously via the video screens. Patient data such as X-ray and ECG

1 images are scanned and transmitted to the command center/remote location upon request  
2 of the intensivist.

3 Remote patient management is utilized in the present invention's critical care  
4 program to supplement traditional onsite care. The rationale underlying the remote patient  
5 management of the present invention is that critically ill patients are inherently unstable  
6 and require continuous expert care that is not now offered in existing ICU monitoring  
7 regimens. Further, remote monitoring allows a single intensivist to care for patients in  
8 multiple ICU locations, thereby creating an efficiency that makes continuous care feasible.

9 Remote intensivist care of the present invention is proactive. Intensivists will  
10 order needed therapies and check results of tests and monitor modalities in a more timely  
11 fashion than is currently offered. Patients can be observed visually when needed using the  
12 ceiling-mounted cameras in each room.

13 Command center/remote location personnel communicate with ICU staff through  
14 videoconferencing and through "hot phones," which are dedicated telephones directly  
15 linked between the command center/remote location and the ICU. These communications  
16 links are used to discuss patient care issues and to communicate when a new order has  
17 been generated.

18 Intensivists document important events occurring during their shift in progress  
19 notes generated on the command center/remote location computer terminal.

20 Intensivists detect impending problems by intermittently screening patient data,  
21 including both real time and continuously stored vital sign data. Patient severity of illness  
22 determines the frequency with which each patient's data is reviewed by the intensivists.

23 A video visitation system allows Remote Visitation Participants (RVPs) at remote  
24 terminals to participate in a video/audio conferencing session with a Local Visitation  
25 Participant(s) (LVPs) (e.g., the patient or the patient's caregivers) at a patient site.

#### 26 **BRIEF DESCRIPTION OF THE DRAWINGS**

27 Figure 1 illustrates the logical data structure for billing, insurance and demographic  
28 information

29 Figure 1A illustrates the logical data structure for billing, insurance and  
30 demographic information (cont)

31 Figure 2 illustrates the command center logical data structure

32 Figure 2A illustrates the command center logical data structure (cont)

- 1           Figures 3 illustrates the logical data structure for creating a medical history
- 2           Figure 4 illustrates the logical data structure for creating notes relating to patient
- 3           treatment and diagnosis
- 4           Figure 4A illustrates the logical data structure for creating notes relating to patient
- 5           treatment and diagnosis (cont)
- 6           Figure 4B illustrates the logical data structure for creating notes relating to patient
- 7           treatment and diagnosis (cont)
- 8           Figure 5 illustrates the logical data structure for entry of medical orders
- 9           Figure 6 illustrates the logical data structure for patient care, laboratory testing and
- 10          diagnostic imaging
- 11          Figure 6A illustrates the logical data structure for patient care, laboratory testing
- 12          and diagnostic imaging (cont)
- 13          Figure 7 illustrates the logical data structure for categories of information that are
- 14          permitted to be presented to intensivists and other care givers by the system
- 15          Figure 8 illustrates the logical data structure for documenting patient vital signs
- 16          Figure 8A illustrates the logical data structure for documenting patient vital signs
- 17          (cont)
- 18          Figure 9 illustrates the distributed architecture of the present invention
- 19          Figure 10 illustrates the system architecture of the present invention
- 20          Figure 11 illustrates the decision support algorithm for decision support algorithm
- 21          for diagnosis and treatment of pancreatitis.
- 22          Figure 12 illustrates the vital signs data flow.
- 23          Figure 13A illustrates capture and display of diagnostic imaging.
- 24          Figure 13B illustrates establishing videoconferencing in the present invention.
- 25          Figure 14 illustrates the physician resources order writing data interface of the
- 26          present invention.
- 27          Figure 15 illustrates the physician resources database data interface of the present
- 28          invention.
- 29          Figure 16 illustrates the automated coding and billing system integrated with the
- 30          workflow and dataflow of the present invention.
- 31          Figure 17 illustrates the order writing data flow of the present invention.
- 32          Figure 18 illustrates the event log flow of the present invention.

- 1           Figure 19 illustrates the smart alarms implementation of the present invention.
- 2           Figure 20 illustrates the procedure note creation and line log for the present
- 3 invention.
- 4           Figure 21 illustrates the acalculous cholecystitis decision support algorithm
- 5           Figure 22 illustrates the adrenal insufficiency decision support algorithm
- 6           Figure 23 illustrates the blunt cardiac injury decision support algorithm
- 7           Figure 24 illustrates the candiduria decision support algorithm
- 8           Figure 25 illustrates the cervical spine injury decision support algorithm
- 9           Figure 26 illustrates the oliguria decision support algorithm
- 10          Figure 26A illustrates the oliguria decision support algorithm (cont)
- 11          Figure 26B illustrates the oliguria decision support algorithm (cont)
- 12          Figure 27 illustrates the open fractures decision support algorithm
- 13          Figure 28 illustrates the pancreatitis decision support algorithm
- 14          Figure 29 illustrates the penicillin allergy decision support algorithm
- 15          Figure 30 illustrates the post-op hypertension decision support algorithm
- 16          Figure 31 illustrates the pulmonary embolism decision support algorithm
- 17          Figure 31A illustrates the pulmonary embolism decision support algorithm (cont)
- 18          Figure 32 illustrates the seizure decision support algorithm
- 19          Figure 33 illustrates the SVT determination decision support algorithm
- 20          Figure 33A illustrates the SVT unstable decision support algorithm
- 21          Figure 34 illustrates the wide complex QRS Tachycardia decision support
- 22 algorithm
- 23          Figure 34A illustrates the wide complex QRS Tachycardia decision support
- 24 algorithm (cont)
- 25          Figure 35 illustrates the assessment of sedation decision support algorithm
- 26          Figure 35A illustrates the assessment of sedation decision support algorithm (cont)
- 27          Figure 36 illustrates the bolus sliding scale midazolam decision support algorithm
- 28          Figure 37 illustrates the sedation assessment algorithm decision support algorithm
- 29          Figure 38 illustrates the short term sedation process decision support algorithm
- 30          Figure 39 illustrates the respiratory isolation decision support algorithm
- 31          Figure 40 illustrates the empiric meningitis treatment decision support algorithm
- 32          Figure 41 illustrates the ventilator weaning decision support algorithm

1 Figure 41A illustrates the ventilator weaning decision support algorithm (cont)

2 Figure 42 illustrates the warfarin dosing decision support algorithm

3 Figure 43 illustrates the HIT-2 diagnostic decision support algorithm

4 Figure 44 illustrates a video visitation system according to an alternate  
5 embodiment of the present invention

## 6 Definitions of Terms and Data

7 **Definitions of Modules** In the following Detailed description of the Invention, a  
8 number of modules and procedures are described. For purposes of definitions, the  
9 following module definitions apply and are more fully amplified in the descriptions of the  
10 figures that follow:

### 11 Term Definitions:

12 Following are a series of definitions for certain terms used in this specification:

13 Insurance carrier: This is a table of all the valid insurance carriers listed in the  
14 system of the present invention.

15 Patient guarantor: Provides the insurance guarantor information for a given patient.

16 Patient information: Provides demographic information for each patient.

17 Medical event date history: This contains the various disorders of the patient and  
18 the dates associated with major medical events relating to those disorders.

19 Medical history: Contains non-major system medical history of a patient.

20 Drug: Contains what medication and allergies have been identified for a patient at  
21 admission.

22 Address: Contains the address or addresses for a given patient.

23 Patient visit: There may be multiple records for any given patient, since the patient  
24 may visit the ICU on more than one occasion. This file contains a record of each visit to  
25 an ICU by a patient.

26 Physician-patient task: Contains the task that had been defined for each patient.

27 Present illness: This contains a textual description of the patient illness for the  
28 specific ICU visit.

29 Physical exam: This contains the information gathered as a result of a physical  
30 examination of the patient during the admission to the ICU.

31 Surgical fluids: This provides all the information related to the fluids provided  
32 during surgery.

1           Surgery: This contains all information pertaining to any surgical procedure  
2 performed on a patient while the patient is at the ICU.

3           Patient admit: This provides general information that needs to be gathered when a  
4 patient is admitted into the ICU.

5           Medical orders: This provides the general information for all types of medical  
6 orders associated with a given patient.

7           Daily treatment: This contains the treatment provided for a given patient on a given  
8 day.

9           Daily diagnosis: This contains the daily diagnosis for a given patient, which  
10 includes neurological, cardiological, pulmonary, renal, endocrinological, and any other  
11 diagnosis that may be associated with a patient.

12           Vital sign information is also critical to the administration of care in the ICU. A  
13 number of different modules collect information relating to patient vital signs. For  
14 example:

15           Patient admit: This provides the general information that needs to be gathered  
16 when a patient is admitted to the ICU.

17           Patient visit: This contains a record of each visit to an ICU by a patient.

18           Patient: Provides demographic information for each patient.

19           Vital sign header: This contains general information related to the vital sign data  
20 for the particular patient.

21           Vital sign: Contains the vital sign data taken at specific intervals for a given  
22 patient.

23           Hospital: This contains identifying information for a particular hospital where the  
24 care is given.

25           ICU bed: Contains the association for identifying which beds are in a given ICU.

26           Command center/remote location definitions and modules have also been created  
27 for the present invention to allow for the orderly storage and retrieval and entering of data.

28           For example:

29           Physician-physician (such as nurses and LPN and the like): Contains the names of  
30 all of the physicians and physician extenders for the command center/remote location as  
31 well as for ICUs associated with the command center/remote location.

1           Communication: Contains all of the various types of communication vehicles used  
2 to contact an individual physician or physician extender.

3           Physician role: Contains the role a physician is playing for a given patient, (i.e.,  
4 primary care, consultant, etc.)

5           Patient: Provides demographic information for each patient.

6           Command center/remote location: Provides identifying information for a particular  
7 command center/remote location.

8           Hospital: Contains identifying information for a particular hospital wherein an ICU  
9 is located.

10          ICU: Contains identifying information for an ICU at a hospital.

11          ICU bed: Contains the association for identifying which beds are in a given  
12 hospital.

13          ICU patient location: Provides the association between an ICU and a patient and  
14 identifies where a patient is located within an ICU in a particular hospital.

15          The order entry functionality of the present invention provides a critical service for  
16 obtaining information on the patient during admission, medical orders, and procedures  
17 provided to the patient during the ICU stay. For example:

18          Radiology: Contains all radiology performed on a particular patient.

19          Radiology results: Contains the results of each radiology test performed on the  
20 particular patient.

21          Drugs: Contains all relevant information for all the drugs that a patient has been  
22 administered.

23          Laboratory: Contains all laboratory tests ordered for a patient.

24          Microbiology result: Contains the results of microbiology organisms taken on a  
25 patient.

26          Laboratory result: Contains the results for a laboratory test ordered for a particular  
27 patient.

## 28                           **DETAILED DESCRIPTION OF THE INVENTION**

29          The present invention is a system and method for remote monitoring of ICU's from  
30 a distant command center/remote location. By monitoring a plurality of ICU's remotely,  
31 intensivists can better spread their expertise over more ICU beds that heretofore



1       achievable. The presence of 24-hour a day/7 day-per-week intensivist care dramatically  
2       decreases the mortality rates associated with ICU care.

3               Referring to Figures 1 and 1A, the Billing and Demographic data structure of the  
4       present invention is illustrated. Patient demographic information **9010** is collected on the  
5       particular patient. This information comprises all the typical kinds of information one  
6       would normally gather on a patient such as first name, last name, telephone number,  
7       marital status, and other types of information. Patient insurance information **9012** is  
8       collected and associated with the patient demographic information **9010**. Patient  
9       insurance information **9012** relates to information on the type of accident and related  
10      information such as employment, employer name, place of service, and other information  
11      that would relate to the accident that actually occurred (if at all) and which would have to  
12      be reported to an insurance agency. This information is associated with the patient  
13      demographic information which assigns the unique patient ID to the particular patient.

14             Insurance plan information **9008** is also created and stored and comprises  
15      insurance carrier ID's, the plan name, policy number, and group number. This  
16      information on the insurance plan **9008** is also associated with the patient ID and  
17      demographic information **9010**.

18             Physician information **9002** is also created and stored for each physician associated  
19      with the system of the present invention. Information such as first and last name,  
20      credentials, and other information concerning the physician is saved. In addition, the  
21      physician's role is identified **9004** and information concerning the physician and the  
22      physician's role is associated with the particular patient via the patient ID stored in the  
23      demographic information **9010**.

24             Patient's are entered into the hospital by a hospital representative **9006** who has a  
25      representative ID which also is ultimately associated with the patient ID. In addition,  
26      communications data **9000** is stored concerning how a representative can be reached (cell  
27      phone, home phone etc.).

28             Referring now to Figure 1A, the Overall Billing and Insurance data structure is  
29      illustrated. An insurance provider number **9014** is also stored in the system. Each  
30      physician is given a provider number and provider ID by each insurance company. Thus  
31      data must be stored regarding the ID that is given to a particular physician by each  
32      insurance provider. This information is also stored and can be associated ultimately with

1 treatment of the patient.

2 Each patient admitted to the hospital and to the ICU has a patient visit ID  
3 associated with the patient **9017**. This visit ID has patient ID information, ICU  
4 information, admission date, and other information relevant to the specific visit. This  
5 information is illustrated in Figure 1A. The visit ID **9017** is associated with the patient ID  
6 **9010** so that each visit can be tracked by patient.

7 Insurance carrier information **9018** is stored by the system and is associated with  
8 the insurance plan information **9008** as appropriate. Thus the particular insurance carrier  
9 with its name, address, and other identifying information **9018** is associated with the type  
10 of plan **9008** carried by the patient. The insurance carrier information **9018** together with  
11 the insurance plan information **9008** is associated with the patient via the patient ID  
12 information **9010**.

13 Patient address information **9020** and **9022** are collected for each individual patient  
14 and associated with the patient demographic information **9010**. If there is a patient  
15 guarantor, this information is obtained and stored with information on the guarantor **9026**.

16 Such information as the guarantor's first and last name, date of birth, and other  
17 information is stored and is illustrated in Figure 1A. Further, the guarantor's address **9024**  
18 is also collected and ultimately associated with the patient demographic information **9010**.

19 Referring to Figures 2 and 2A, the Command Center logical data structure is  
20 illustrated.

21 The various information associated with demographic and insurance information is again  
22 used to manage the care and operations of the command center. Therefore,  
23 communications information **9000** is combined with physician and physician extender (i.e.  
24 nurse, LPN and the like) information **9002** and physician role **9004** to be associated with  
25 the demographic information **9010**. The patient visit information **9017** together with this  
26 information is associated with the patient's location which has a unique identifier **9030**.  
27 Each location ID has patient ID information and visit ID information associated with it.

28 Referring now to Figure 2A, the Command Center logical data structure  
29 illustration continues. Each ICU bed has an associated location ID which comprises  
30 hospital ICU information, room number, and bed number **9038**. In addition, and as  
31 described earlier, instrumentation such as cameras are also associated with the particular  
32 patient. Therefore the camera setting **9040** will have a location ID relating to the ICU bed

1 as well as have camera value settings and associated camera identifier information.

2 Each ICU bed **9038** is associated with an ICU **9032**. Each ICU has information  
3 associated with it that uniquely identifies the ICU as being associated with the particular  
4 hospital, and having particular phone numbers, fax numbers, work space addresses, and  
5 other information, that help to identify the ICU.

6 As noted above, each ICU is associated with a hospital **9034**. Each hospital has a  
7 unique identifier, as well as its own name, address, and other identifying information.  
8 Further, since each hospital ICU is to be coordinated through a remote command center,  
9 information on the remote command center **9036** is associated with the hospital  
10 information. Each command center has a unique ID and has associated address  
11 information stored as well.

12 Thus in the Command Center logical data structure, patient ID information **9010** is  
13 linked to a patient location **9030** which in turn is associated with an ICU bed **9038** each of  
14 which beds are uniquely associated an ICU **9032** which is associated with a hospital **9034**  
15 which in turn has the ICU managed by a command center **9036**.

16 An integral part of the system of the present invention is the recording of medical  
17 history. Referring to Figure 3, the logical relationship among data elements for medial  
18 history is illustrated. Patient visit information **9017** combined with the physician-  
19 physician extender information **9002** is combined with specific note-taking information  
20 **9042**. The note information comprises the date and time the notes are taken as well as the  
21 note type. The note ID is fed information from the medical history item **9044**, which has  
22 its own unique medical ID associated with it. This information comprises medical text,  
23 category of information, and other information relevant to the medical history. As noted,  
24 this information for medical history **9044** is associated with a note ID **9042**, which in turn  
25 is associated with the patient visit and physician information **9017** and **9002**.

26 Referring to Figure 4, 4A, and 4B, the note-keeping logical data structure of the  
27 present invention is illustrated. As noted earlier, the note ID **9042** combines information  
28 from visit ID, treating physician, and other information relating to the time the note was  
29 entered. Other information is associated with the note ID. Referring first to Figure 4, the  
30 patient visit information **9017**, is associated with the note ID **9042**. Various procedural  
31 information **9046** is kept by the system of the present invention and is associated with the  
32 visit ID **9017**. Physicians are able to create free text patient illness notations **9048** and

1 associate them with the note **9042**. Similarly, free text information regarding functioning  
2 of the system **9050** is permitted and also associated with notes regarding the particular  
3 patient and procedure **9042**.

4 Specific notes regarding, for example, surgical procedures are also kept. Surgery  
5 notes **9054** are associated with a particular note ID and have such information as  
6 anesthesia, surgical diagnosis, elective information, and other related surgical information.

7 Surgical fluids **9052** administered during the course of surgery are associated with the  
8 surgery information **9054**. Additionally, any surgical complications **9056** are noted and  
9 also associated with the surgery which in turn has an associated note ID.

10 Referring now to Figure 4A, the logical data structure for notes and its description  
11 is continued. An assessment plan **9058** is created and associated with the same note ID for  
12 the particular patient. The plan has a free text field that allows a physician to create the  
13 appropriate assessment plan and associate it with a note ID **9042**.

14 Various daily notes are also kept and associated with the individual note ID **9042**.  
15 For example, the daily mental state **9060** is recorded to document the mental state of the  
16 patient. The daily treatment **9062** administered to the patient is associated with the unique  
17 note ID. The daily diagnosis **9068** is also created and associated with unique note ID  
18 **9042**.

19 Any unstable conditions are also noted **9070** and records kept of those conditions.  
20 Similarly mortality performance measures (MPM) information **9072** is kept and associated  
21 with the unique note ID. To the extent that any physical exam **9074** is administered, that  
22 physical exam and any free text created by the physician is associated with the unique ID  
23 and records kept. Allergy information **9076** for the particular patient is also created and  
24 stored along with the allergy type, and allergy name. This information is uniquely  
25 associated with the note ID. Referring now to Figure 4B, the Logical Data Structure for  
26 the Notes Creation and Storage description is continued. A specific note item record **9078**  
27 is also kept and associated with unique note ID. This note item comprises the principal  
28 diagnosis, the chief complaint, the past history of the patient, the reason for the note, and  
29 various other identifications and flags of information which help in documenting the  
30 patient's condition.

31 Any drugs that are administered to the patient, including dosage, type, and number  
32 **9086** is kept and associated with the unique note ID **9042**.

1           Procedural note items are also documented **9082**. Procedural notes involve the  
2           procedural type, the principal diagnosis, the procedural location, procedural indications,  
3           and other information of a procedural nature. Procedural description information **9088** is  
4           kept as input to the procedural note item. This information is also associated with a  
5           procedural evaluation **9084** which comprises text describing the procedural evaluation that  
6           occurred, These three items, the procedural description **9088**, procedural evaluation **9084**,  
7           and procedural note items **9082**, are all uniquely associated with the note ID **9042**.

8           Referring now to Figure 5, the Logical Data Structure of the Medical Order  
9           Functionality of the Present Invention is illustrated. Each medical order **9092** has a unique  
10          order ID associated with it. This information derives its uniqueness from the visit ID, the  
11          representative ID, and various information about the date in which the order was created  
12          and other such relevant information. Any non-drug orders **9090** are associated with a  
13          unique non-drug order ID. The order is classified, identified, and free text can be created  
14          by the physician to describe the order. This information in the non-drug order **9090** is  
15          associated with the unique medical order for that particular patient **9092**.

16          Again physician and physician extender identification information **9002** is also  
17          uniquely associated with the medical order to identify the physician involved in creating  
18          the particular order in question.

19          Drug orders **9094** are created each with its own unique drug order ID. Various  
20          information is collected as part of the drug order including the type of drug, the dosage,  
21          start date, frequency, stop date, to name but a few elements typical of a drug order. The  
22          drug order information **9094** is associated with the unique medical order ID **9092** assigned  
23          to that particular patient. All of the medical order information is associated with patient  
24          visit information **9017** which allows that information to be uniquely identified with a  
25          particular patient for a particular visit.

26          Referring again to Figure 4B, the system is also capable of annotating and storing  
27          various log items **9080**. For example, an event log item is given a number, a patient  
28          profile item has its own number, as do neurological, cardiographic, pulmonary, renal, and  
29          other events can have log items associated with them and may be used as input to any of  
30          the note taking of the present invention.

31          Referring to Figure 6 and 6A, the logical data structure of the patient care  
32          functionality of the present invention is illustrated. Each patient visit with its unique ID

1       **9017** has a number of other pieces of information associated with it. For example,  
2       physician-patient tasks are tracked **9098** and have a unique task ID associated with them.  
3       The patient code status **9096** is documented and associated with the physician-patient task  
4       **9098** task ID. This information is uniquely associated with the patient visit via the the  
5       patient visit ID **9017**.

6       Laboratory information **9100** has a unique lab ID associated with it. That  
7       information is keyed to the visit ID and records the specimen taken, the date it was taken,  
8       and various other information germane to the laboratory procedure involved. Other lab  
9       procedures **9102** are also documented with another unique ID. "Other" lab ID is  
10      associated with the laboratory ID **9100** which again is uniquely associated with the  
11      particular patient.

12      Microbiological studies **9104** are documented together with the date and the date  
13      taken and the type of study involved. Any study of microorganisms **9106** is documented  
14      with a unique microorganism ID. Micro sensitivities **9108** which record the sensitivity to  
15      microorganisms and certain antibiotics is recorded and associated with the microorganism  
16      ID **9106**. This information in turn is associated with a microbiological study **9104**, all of  
17      which is associated with the unique patient visit ID **9107**.

18      Respiratory studies **9101** are also recorded with unique identification numbers and  
19      a description. This information is again associated with the patient visit ID **9017**.

20      Referring now to Figure 6A, the logical data structure of the patient care  
21      functionality of the Present Invention is further illustrated. Other organism studies **9118**  
22      are also conducted to determine any other conditions associated with microorganisms that  
23      might exist with the particular patient. This other organism information **9118** is associated  
24      with the microorganism studies **9106** which in turn is associated with the microbiology  
25      category of information of the present invention **9104**.

26      Various diagnostic imaging also takes place and is recorded. This image  
27      information **9114** has unique image ID associated with each image and comprises  
28      associated information such as the image type, the date performed, and other information  
29      relevant to the diagnostic imagery. The result of the image taken **9116** is also uniquely  
30      identified with the image ID and a unique image result ID. This information is associated  
31      with the image information **9114** which again is uniquely associated with the patient visit  
32      ID.

1           Various intake and output for the patient's biological functioning is recorded **9110**.  
2           Intake and output total **9112** is recorded and uniquely associated with the intake/output  
3           identification note **9110**. Intake/output totals **9112** also comprised the weight the total  
4           taken in, the total out, and five-day cumulative totals for biological functioning of the  
5           particular patient.

6           Referring to Figure 7, The Logical Data Structure Concern with Reference  
7           Information for the present invention is illustrated. This data structure allows only certain  
8           ranges of data to be input by care givers into the system. This is accomplished by having  
9           categories of information **9120** each category capable of having only certain values.  
10          Similarly, each type of data **9126** associated with each category is only permitted to have  
11          certain values. This combination of Category and Type results in a Combined ID **9122**  
12          which can be used in combination with certain values **9128** to create a value and  
13          combination **9124** that can be presented to a care giver viewing and entering data. This  
14          effectively limits errors in data entry by only allowing certain values to be entered for  
15          given types of data. For example, if only milligrams of a medication are supposed to be  
16          administered, this data structure prevents a care giver from administering kilograms of  
17          material since it is not a permitted range of data entry. The "nextkey" function **9027** is the  
18          function that keeps track of the ID's that are given during the administration of the present  
19          invention. This function insures that only unique ID's are given and that no identical ID's  
20          are given to two different patient's for example.

21          Referring to Figure 8, the Logical Data Structure of the Vital Signs Functionality  
22          of the Present Invention is illustrated. Vital sign header information **9120** is created and  
23          uniquely associated with the visit ID for the particular patient. This header information  
24          comprises a date-time stamp combined with hospital information, medical reference  
25          numbers, and identification of the patient. Vital sign details **9122** are also created and  
26          uniquely date-time stamped and associated with the particular visit ID for the patient. This  
27          information comprises all manner of vital sign information relating to blood pressure,  
28          respiration, and other factors. Vital sign information is associated with the patient visit  
29          **9017** and the demographic information concerning the patient **9016**. Such associations of  
30          information can be the basis for later studies.

31          Referring to Figure 8A, Additional Vital Sign Logical Data Structures are  
32          illustrated. For example, a vital sign log header **9120** is created using the unique hospital

1 ID and medical record numbers. Other information such a patient name, and date-time  
2 stamp are also stored. Vital sign log details **9124** are created and associated with the vital  
3 sign log header **9120**. For example, blood pressure measurements, respiration, and other  
4 factors are all detailed for a particular hospital ID. It should be noted that all vital sign  
5 data is logged in and kept by the systems of the present invention. Where vital sign  
6 information is received but cannot be associated with a particular patient, such  
7 communications are noted as errors.

8 Vital sign error details **9126** are also recorded and associated with a particular  
9 hospital. Information and the vital sign error detail also comprises heart rate, blood  
10 pressure, and other information. This information is associated with a vital sign error  
11 header **9130** which is associated with the hospital identifier and the patient first and last  
12 name and other information. Various vital sign error codes **9128** exist with the present  
13 invention and are used in association with the vital sign error detail **9126**. This  
14 information however relates to communications of vital sign data that are deemed “errors”  
15 as noted above.

16 Care Net patient location **9132** is recorded and associated with a particular hospital  
17 ID and location ID for the particular patient. Carenet is a proprietary product designation  
18 of Hewlett-Packard and is kept by the system of the present invention since it identifies the  
19 equipment from which measurements come. The ICU bed information **9038** is associated  
20 with the Care Net patient location **9132**.

21 Referring to **Figure 9**, the distributed architecture of the present invention  
22 is shown. In concept, the distributed architecture comprises a headquarters component  
23 **200**, a command center/remote location **202**, and a hospital ICU **204**, which, while  
24 represented as a single hospital in this illustration, in the preferred embodiment comprises  
25 several hospital ICUs at different locations. The headquarters unit **200** comprises a  
26 database server and data warehouse functionality, together with a patient information front  
27 end. The patient information front end **206** provides patient specific information to the  
28 command center/remote location. The database server/warehouse function **208** comprises  
29 the amassed information of a wide variety of patients, in their various conditions,  
30 treatments, outcomes, and other information of a statistical nature that will assist clinicians  
31 and intensivists in treating patients in the ICU. The headquarters’ function also serves to  
32 allow centralized creation of decision support algorithms and a wide variety of other



1 treatment information that can be centrally managed and thereby standardized across a  
2 variety of command center/remote locations. Further, the database server/data  
3 warehousing functionality **208** serves to store information coming from command  
4 center/remote locations replicating that data so that, in the event of a catastrophic loss of  
5 information at the command center/remote location, the information can be duplicated at  
6 the command center/remote location once all systems are up and running.

7 At the hospital ICU **204**, each patient room **232, 234** has a series of bedside  
8 monitors and both video and audio monitoring of each patient in the patient room. Each  
9 ICU further has a nurse's station with a video camera and monitor **230** so that  
10 videoconferencing can go on between the nurses and doctors at the nursing station and  
11 those intensivists at the command center/remote location. The monitoring equipment at  
12 the ICU is served by a monitor server **236**, which receives and coordinates the  
13 transmission of all bedside monitoring and nurses station communication with the  
14 command center/remote location. Finally, each ICU has a patient information front end  
15 **228**, which receives and transmits to the command center/remote location information  
16 concerning the identity and other characteristics of the patient.

17 Command center/remote location **202** comprises its own video capture and  
18 monitoring capability **212** in order to allow the intensivists to view the patients and  
19 information from the bedside monitoring as well as to have videoconferencing with the  
20 nursing station and with patients as the need arises. Information from the monitor server  
21 **236** at the hospital ICU is served to an HL7 (the language for transmitting  
22 hospital/patient/diagnostic data) gateway **214** to a database server **222**. In this fashion,  
23 information from the bedside monitors can be stored for current and historical analysis.  
24 Monitor front ends **216** and **218** allow technicians and command center/remote location  
25 personnel to monitor the incoming data from the patient rooms in the ICU. Information  
26 from the patient information front end **228** is provided to an application server **224**, having  
27 its own patient information front end **226** for aggregating and assembling information in  
28 the database **222** that is associated with individual patients in the ICU.

29 It is expected that there will be a great deal of concurrent hospital data that is  
30 necessary to the implementation of the present invention. It is therefore expected that  
31 there will be a legacy database system **210** having a front end **220** from which intensivists  
32 and command center/remote location personnel can retrieve legacy database information.

1 Referring to **Figure 10**, a system architecture of one embodiment of the present  
2 invention is illustrated. Headquarters **200** comprises an application server **238**, an NT file  
3 server **240**, and Sun SPARC Enterprise 250 **242** and Enterprise network management  
4 system **244**, a Cisco 3600 router **246**, a Cisco 2924 switch **248**, and a hot phone **250**. The  
5 application server **238** is designed to monitor and update those applications used at the  
6 command center/remote location. The NT file server serves to monitor, store, and  
7 replicate information coming from the command center/remote locations. The SPARC  
8 Enterprise 250 server **242** is a disc storage server, for storing and serving information,  
9 such as practice guidelines, algorithms, patient information, and all matter of other  
10 information records that must be stored in order to support the present invention. As  
11 explained below, the SPARC Enterprise 250 server and other components are such as  
12 routers and switches are commonly used in the ICU, the command center/remote location,  
13 and the headquarters. For example:

14 The Cisco 3600 router is a multi-function device that combines dial access,  
15 routing, and local area network (LAN) to LAN services, as well as the multi-service  
16 integration of voice, video, and data in the same device. This is necessary, since the  
17 various command center/remote locations, headquarters, and intensive care units all must  
18 integrate and transmit video, audio, and data among the various entities.

19 The Cisco 7204 is a router which provides high speed LAN interconnect, virtual  
20 private networks, and Internet access, all of which is required for providing the  
21 communication in the network of the present invention; and

22 The Cisco 2924 switch is an autosensing fast ethernet switch, allowing networked  
23 multimedia and virtual LAN support. Multi-level security is also offered in the switch to  
24 prevent unauthorized users from gaining access and altering switch configuration. These  
25 components are also identified in the figures (below).

26 The particular commercial systems named here are given as but some examples of  
27 equipment available today. The function of these equipment is the important factor.  
28 Other similar or improved equipment can also be utilized.

29 The network management system **244** allows the entire traffic and condition of the  
30 network to be monitored and to allow maintenance to take place. The router **246** and  
31 switch **248** is used for communication with the various command center/remote locations

1 that are served by the Headquarters component. The Headquarters component interacts  
2 via frame relay with the command center/remote location **202**.

3 Command center/remote location **202** comprises an applications server **262** for the  
4 purpose of running various applications for the intensivists and command center/remote  
5 location staff. The NT file server **264** at the command center/remote location allows  
6 patient files, historical files, algorithms, practice standards, and guidelines, to be served to  
7 the clinicians and intensivists to assist in monitoring the patients. The Sun SPARC  
8 Enterprise 250 **266** is used to for storage purposes as noted above. The Enterprise network  
9 management system **268** monitors the overall health of the network of command  
10 center/remote locations and intensive care units as well as the functionality of the  
11 individual pieces of equipment within the command center/remote location. A Cisco 2924  
12 switch **256** and Cisco 7204 router **258**, combined with the Cisco 3600 router **260** allows  
13 for point to point communication over a T1 line, with a plurality of intensive care units  
14 located remotely from the command center/remote location. Hot phones **252** and **254**  
15 allow communication with the headquarters and the intensive care unit.

16 Intensive care unit **204** comprises a Cisco 2924 switch **272** for the purpose of  
17 interfacing with the various audio-video feeds **274**, **276** from the various patient rooms  
18 and the nursing station. A local work station **280** is connected to a scanner **282** which  
19 allows data to be input, scanned, and communicated via the point to point T1  
20 communications to the command center/remote location. Further, the workstation **280**  
21 provides for textual advice and patient orders to be delivered to the intensive care unit for  
22 execution. The intensive care unit also comprises a laser printer **284** for the printing of  
23 patient orders and other information relevant to the care of intensive care patients.

24 Referring to **Figure 11**, the videoconferencing/surveillance/imaging components  
25 of the present invention are illustrated. The hospital ICU **204** comprises a series of video  
26 cameras **290**, which are located in patient rooms and at the nurse's station. Control for the  
27 cameras is provided through an RS424 to RS232 converter **288**, with instructions for  
28 imaging emanating from the workstation at the command center/remote location **252**  
29 through the ICU workstation **280** through a multi-port serial controller **286**. Video feed  
30 from the video cameras **290** is provided to an audio-video switcher **292**, which in turn  
31 provides its output to the multi-port serial controller **286** for subsequent viewing at the  
32 nurse's station and at the command center/remote location. Of equal importance is a

1 microphone feed from the patient and from the nurses. That microphone 296 provides its  
2 signal to an audio line amplifier 294, which in turn provides an audio feed to the audio-  
3 video switcher 292. In this way, a patient can provide information, as can nurses who are  
4 visiting the patient during the course of patient care. It is also important that information  
5 of an audio nature be fed to the intensive care unit, both to the patient rooms and to the  
6 nurse's station. To do this, the multi-port serial controller 286 provides an audio signal to  
7 a reverse audio switcher 298, which in turn provides information to speakers 300 that are  
8 located at the nurse's station as well as at the bedside of the patients. Information to the  
9 reverse audio switcher is provided an audio amplifier 302 from information from a video  
10 codec 304, which in turn is connected to the workstation at the ICU. As noted earlier, a  
11 scanner 282 is provided, so that information can be scanned and provided to the command  
12 center/remote location 202 and a hot telephone 278 communicates with a telephone 252 at  
13 the command center/remote location.

14 Referring to **Figure 12** the vital signs data flow is illustrated. The monitoring  
15 system at each ICU bedside comprises a monitoring system for monitoring the vital signs  
16 for the patient. The vital sign monitoring system 450 captures vital sign data 452 and  
17 transmits that vital sign data 454 using the HL7 language (the standard processing  
18 language for hospital data and information). The processor at the ICU processes the vital  
19 sign data for transmission and storage purposes and transmits that information to the  
20 remote location. Vital sign data is then loaded into the data base 458. The data base for  
21 each individual patient is then reviewed and process rules are applied 460 to the vital sign  
22 data. These process rules relate to certain alarming conditions which, if a certain threshold  
23 is reached, provides an alarm to the intensivist on duty. The vital sign alarm 462 is then  
24 displaced to the intensivist who can then take appropriate action. A typical type of rule  
25 processing of the vital sign data might be if blood pressure remains at a certain low level  
26 for an extended period of time, or if heart rate remains high for an extended period of time.  
27 In addition a wide range of other rules are provided which will provide an audible alarm  
28 to the intensivist before a critical situation is reached.

29 In addition to the information being provided to the alarming system for the  
30 intensivist, the vital sign data 464 is also transmitted 466 into a database warehouse 468  
31 comprising vital sign data 470 from not only the individual patient but from all of the  
32 patients being cared for in the ICU. This database warehouse provides the ability to do

1 data mining for trends that can give rise to additional process rules and vital sign  
2 thresholding. In addition to the transmission of vital sign data 454 to the remote site, the  
3 vital sign data is displayed in real time at the ICU 472.

4 Referring to **Figure 13(a)** the diagnostic imaging interaction is illustrated. X-rays  
5 for example, are created and transmitted to the command center 472. Additionally, the  
6 information could be ACT scan, MRI, or any other method of medical diagnostic imaging.  
7 The x-ray image is captured at the command center 474 where it is stored and in addition  
8 displayed on the image monitor 476 for the intensivist to review.

9 Referring to **Figure 13(b)** the interactive video session is illustrated. A video  
10 conferencing session is established 478 regarding a particular patient in an ICU bed.  
11 Using the video cameras in each room and/or at the nurses station at the ICU, the patient  
12 and/or the nurse can be viewed 480. On the other end of the video conferencing session is  
13 the intensivist who can then both visually and orally communicate with the patient and/or  
14 nurse 482.

15 Referring to **Figure 14** the physician resources and order writing data interface is  
16 illustrated. The user interface 484 allows the physicians to access physician resources  
17 486. These resources provide guideline for the treatment of the critically ill. In this  
18 example the intensivist is requested to enter the antibiotic associated with colitis 488. The  
19 system then generates a request for a fecal leukocyte test 490. This request is translated  
20 into an order writing module 496 which results in the actual order for the test 502. Since  
21 the order needs to be transmitted to the appropriate organization for execution, an  
22 appropriate order is generated to the microbiology laboratory 500 in this instance. The  
23 order results are then achieved 506 and the completion of the order is reported to the order  
24 writing assignment manager 496. In addition, the order writing module 502 also results in  
25 a task list 504 of orders for various other individuals in laboratories. In addition, user  
26 interface 484 allows the physician to re-enter the physician resources module at any  
27 particular location with results of the tests. These tests are then fed into the system to  
28 continue with the diagnostic algorithm processing of the patient test results 494. The user  
29 interface also allows interaction with the resident data base 498 Referring to **Figure 15**  
30 the physician resources database data interface is illustrated. User interface 508 allows the  
31 intensivist to interact with the physician resources data base 510. In this example, resident  
32 data base 524 which comprises the identification and background of the resident admitting

1 the patient causes an admission diagnosis 526 to be created. In this example a diagnosis of  
2 pancreatitis is illustrated. This diagnosis of pancreatitis 522 alerts the physician resources  
3 module 510 which causes an entry for the topic pancreatitis 512. The diagnosis algorithm  
4 for pancreatitis 514 is then retrieved and a request for an Apache II score 516 is requested.  
5 The system also requests information for operative data 528 describing what if any  
6 operations have taken place with respect to this patient, vital sign data 530, request for  
7 laboratory information 532, past medical history for the patient 534 and patient  
8 demographics 536. All this information is provided to the Apache II score assignment  
9 manager 538 which assigns an Apache II score based upon weighted composite up to  
10 twenty five different variables. This Apache II score is provided to the Apache II score  
11 request module 516. If the severity based Apache II score is greater than or equal to eight  
12 the diagnostic of the system continue 520. If the Apache II score is less than eight, the  
13 patient is triaged to a none ICU bed 518 since the patient will not necessarily require  
14 intensive care thereby saving relatively scarce resources of the ICU for those who are truly  
15 critically ill.

16 Referring to **Figure 16** the automated coding/billing work flow and data flow is  
17 illustrated. Clearly ICUs must be paid for the care that they give. At the outset of the visit  
18 540 the user interface 542 allows for the input of ICD 9 diagnosis code information  
19 concerning complexity of the case, whether the patient is stable, whether the physician  
20 involved is the attending physician or consulting physician and all other manner of  
21 information required for billing purposes. In addition, resident data 544 is input such as  
22 patient demographics, insurance information, physician, guarantor, the date that the  
23 service is provided. All this information is provided to the data manager 546 which  
24 assembles the required data element for subsequent processing. The data manager sends  
25 the demographic, physician, guarantor, insurance and related information to a bill  
26 generator 548 which begins to assemble of the information to subsequently generate a bill.  
27 Clinical information is provided to the CPT code assignment manager which assigns  
28 codes based upon the scores and user input for bill generation purposes. A history of  
29 present illness (HPI) score 560 is generated along with a review of systems (ROS) score  
30 562. A PFSH score 564 is generated along with a score relating to the physical exam 566.  
31 An MPM score 568 which is a score relating to the severity of the illness is also  
32 generated. All of these various scores are provided to the CPT assignment manager 558.

1 Periodically information is downloaded for management reports **556**. Once all of the  
2 information for the CPT code assignment is generated that information is provided to the  
3 bill generator **548** which assembles all the data elements needed to generate an HCFA1500  
4 claim form. The input for the bill generator is then verified **550** where the physician can  
5 disagree with code assignments return progress notes and generally review the bill. This  
6 smart processing of the HCFA1500 claim form allows for fewer mistakes to be made. If  
7 there is any error or additional information that is required, the verification process fails  
8 the proposed claim form and information regarding that failure is provided back to the  
9 resident data for completion of any missing items. Once an invoice has been verified as  
10 having the appropriate information to be submitted the HCFA1500 claim form is  
11 generated **554**. Additional information is written to a billing data file **552** for importation  
12 to the patient accounting system of the present invention.

13 Referring to **Figure 17** the order writing data flow is illustrated. Order entry user  
14 interface **600** allows the intensivist to order procedures and medication to assist the  
15 patients in the ICU. For example, the intensivist can order an ECG **604**. Thereafter the  
16 order is reviewed and a digital signature relating to the intensivist is supplied **606**. Once  
17 reviewed and signed off, the order is approved **607** and sent to the data output system **610**.  
18 Thereafter the data output system prints the order to the printer in the ICU **616**. For  
19 record keeping purposes the order is exported in the HL7 language to the hospital data  
20 system **618**. In addition the data output system adds an item to the data base that will  
21 subsequently cause an intensivist to check the ECG results. This notification to the task  
22 list is provided to the database **614**. In addition, as part of the database an orders file  
23 relating to the specific patient is also kept. The fact that and ECG has been ordered is  
24 entered in the orders file for that patient.

25 In a similar fashion using the order entry user interface **600** the intensivist can  
26 order medications **602** for a patient. The medication order then is provided to an order  
27 checking system **608**. The order checking system retrieves information from the database  
28 **614** relating to allergies of the patient and medication list which includes medications  
29 which are already being administered to the patient. This allows for the order checking  
30 system to check for drug interactions. Further laboratory data is extracted from the  
31 database **614** and the order checking system checks to insure that there will be no adverse  
32 impact of the recommended dosage upon the renal function of the patient. Once the order

1 checking system 608 is completed, the order is okayed and provided to the order review  
2 and signature module 606. In this module the digital signature of the intensivist is affixed  
3 to the order electronically and the order is approved 607. Thereafter it is provided to the  
4 data output system 610 where again the orders are printed for ICU and 616 and for the  
5 hospital data system. In this case, any medications that are ordered are then provided to  
6 the medications list file in the database 614 so that the complete list of all medications that  
7 are being administered to the ICU patient is current.

8 Referring to **Figure 18** the event log is illustrated. The database 620 contains all  
9 manner of notes and data relating to the particular patient that is admitted to the ICU. For  
10 example, admission notes 622 are taken upon admission of the patient and stored in the  
11 file that is specific to that patient. Progress notes 624 are created during the patients stay  
12 within the ICU to note the progress the patient is making giving the various treatments.  
13 Procedural notes 626 are also created by the intensivist to note what procedures have taken  
14 place and what if any events have occurred associated with those procedures. Laboratory  
15 data such as positive blood cultures are also stored in the file 628 in the database 620.  
16 Further x-ray data 630 and abnormal CT Scan results are stored in the database.

17 The result of these individual files are then provided to an event log manager 632.  
18 For example, admission notes might contain operations performed. Progress notes 624  
19 might relate to the operations performed. This information is provided to the event log  
20 manager 632. Admission information is also input to the event log manager as are a  
21 listing of the procedures administered to the patient. To the extent there are positive blood  
22 cultures in the laboratory data 628 those are provided to the event log manager 632 as are  
23 abnormal CT scan results. All of this information is made available through the user  
24 interface 634. Thus the event log presents in a single location key clinical information  
25 from throughout a patients stay in the ICU. The event log user interface provides  
26 caregivers with a snapshot view of all salient events since admission. All relevant data on  
27 procedures and laboratory tests, etc. are presented chronologically.

28 Referring to **Figure 19** the smart alarms of the present invention are illustrated.  
29 The smart alarm system constantly monitors physiologic data (collected once per minute  
30 from the bedside monitors) and all other clinical information stored in the database (labs,  
31 medications, etc). The periodicity of the collection of data is stated for illustrative  
32 purposes only. It is well within the scope of the present invention to collect physiological



1 data at more frequent time intervals. Thus, monitor **636** provides information in HL7 form  
2 to the interface engine **638**. The physiological data is then formatted by the interface  
3 engine for storage in the database **640** where all patient information is maintained. The  
4 rules engine **642** searches for patterns of data indicative of clinical deterioration.

5 One family of alarms looks for changes in vital signs over time, using pre-  
6 configured thresholds. These thresholds are patient-specific and setting/disease-specific.  
7 For example, patients with coronary artery disease can develop myocardial ischemia with  
8 relatively minor increases in heart rate. Heart rate thresholds for patients with active  
9 ischemia (e.g. those with unstable angina in a coronary care unit) are set to detect an  
10 absolute heart rate of 75 beats per minute. In contrast, patients with known coronary  
11 artery disease in a surgical ICU have alarms set to detect either an absolute heart rate of 95  
12 beats per minute or a 20% increase in heart rate over the baseline. For this alarm, current  
13 heart rate, calculated each minute based on the median value over the preceding 5  
14 minutes, is compared each minute to the baseline value (the median value over the  
15 preceding 4 hours). Physiologic alarms can be based on multiple variables. For example,  
16 one alarm looks for a simultaneous increase in heart rate of 25% and a decrease in blood  
17 pressure of 20%, occurring over a time interval of 2 hours. For this alarm, thresholds were  
18 initially selected based on the known association between changes in these two variables  
19 and adverse clinical events. Actual patient data were then evaluated to determine the  
20 magnitude of change in each variable that yielded the best balance between sensitivity and  
21 specificity. This process was used to set the final thresholds for the rules engine.

22 Alarms also track additional clinical data in the patient database. One alarm tracks  
23 central venous pressure and urine output, because simultaneous decreases in these two  
24 variables can indicate that a patient is developing hypovolemia. Other rules follow  
25 laboratory data (e.g. looking for need to exclude active bleeding and possibly to administer  
26 blood).

27 The purpose of the rules engine is to facilitate detection of impending problems  
28 and to automate problem detection thereby allowing for intervention before a condition  
29 reaches a crisis state.

30 Referring to **Figure 20** the procedural note-line log is illustrated. This log allows  
31 clinicians to evaluate the likelihood that a given procedure might result in further  
32 complications. In this example presented in this Figure 20 a catheter removal is illustrated.

1       When a new catheter is inserted in a patient 648 a procedural note is created on the  
2       procedure note creation user interface 646. The note is reviewed and a digital signature is  
3       attached to the note to associate the note with a particular intensivist 654. The procedure  
4       is then approved and is provided to the data output system 656. The procedural note is  
5       then printed on the printer in the ICU 658 and is exported in HL7 language to the hospital  
6       data system 660. In addition, this also triggers a billing event and the data output system  
7       provides appropriate output to the billing module 662 to generate an invoice line item. In  
8       addition, the note is stored in the emergency medical record associated with the patient in  
9       the database 664. In addition, the line log is updated in the database 664 to show what  
10      procedure was administrated to a patient at what time. If there is an existing catheter, that  
11      is displayed to the intensivist at the procedure note creation user interface 646. This  
12      would show an existing catheter changed over a wire 650. That information is provided to  
13      the line id module 652 which extracts information from the line log in the database 664.  
14      This information results in a note being created and provided to the note review and  
15      signature module 664. Thus the line log contains, for each patient, relevant information  
16      about all in-dwelling catheters, including type and location of the catheter, insertion date,  
17      the most recent date that the catheter was changed over a wire, and the date the catheter  
18      was removed. This information helps clinicians evaluate the likelihood that a given  
19      catheter is infected and guides its subsequent management of that procedure.

20      Evidence-based Guidelines, Algorithms, and Practice Standards

21      Decision Support Algorithms

22             In order to standardize treatment across ICUs at the highest possible level, decision  
23      support algorithms are used in the present invention. These include textual material  
24      describing the topic, scientific treatments and possible complications. This information is  
25      available in real time to assist in all types of clinical decisions from diagnosis to treatment  
26      to triage.

27             All connections among components of the present invention are presently with a  
28      high bandwidth T-1 line although this is not meant as a limitation. It is anticipated that  
29      other existing and future high bandwidth communication capabilities, both wired and  
30      wireless, as well as satellite communications will be suitable for the communications  
31      anticipated for the present invention.

1           As noted earlier, a key objective of the present invention is to standardize care and  
2 treatment across ICUs. This is effective in the present invention by providing decision  
3 support to intensivists as well as information concerning the latest care and practice  
4 standards for any given condition. As noted in EVIDENCE-BASED GUIDELINES  
5 ALGORITHMS & PRACTICE STANDARDS below, a wide variety of conditions is  
6 noted. Each of the conditions has an associated guideline of practice standard that can be  
7 presented to the intensivist who might be faced with that particular condition in a patient.  
8 These guidelines of practice standards can be accessed at the command center/remote  
9 location or at the ICU to assist in the treatment of the patient. Thus, the general categories  
10 of cardiovascular, endocrinology, general, gastrointestinal, hematology, infectious  
11 diseases, neurology, pharmacology, pulmonary, renal, surgery, toxicology, trauma all have  
12 guidelines and practice standards associated with them.

13  
14                               **EVIDENCE-BASED GUIDELINES**  
15                               **ALGORITHMS & PRACTICE STANDARDS**

16                               **DECISION SUPPORT**  
17

**CARDIOVASCULAR**

BRADYARRHYTHMIAS  
CARDIOGENIC SHOCK  
CARDIO-PULMONARY RESUSCITATION GUIDELINES  
CONGESTIVE HEART FAILURE  
EMERGENCY CARDIAC PACING  
FLUID RESUSCITATION  
HYPERTENSIVE CRISIS  
**IMPLANTABLE CARDIO-DEFIBRILLATORS**  
INTRA-AORTIC BALLOON DEVICES  
MAGNESIUM ADMINISTRATION IN PATIENTS  
MANAGEMENT OF HYPOTENSION, INOTROPES  
MYOCARDIAL INFARCTION  
MI WITH LEFT BUNDLE BRANCH BLOCK  
PA CATHETER GUIDELINES & TROUBLE-SHOOTING  
PERMANENT PACEMAKERS & INDICATIONS  
PULMONARY EMBOLISM DIAGNOSIS  
PULMONARY EMBOLISM TREATMENT  
SUPRA-VENTRICULAR TACHYARRHYTHMIAS

UNSTABLE ANGINA  
 VENOUS THROMBOEMBOLISM PROPHYLAXIS  
 VENOUS THROMBOSIS: DIAGNOSIS & TREATMENT  
 VENTRICULAR ARRHYTHMIAS

### **ENDOCRINOLOGY**

ADRENAL INSUFFICIENCY  
 DIABETIC KETOACIDOSIS  
 HYPERCALCEMIA: DIAGNOSIS & TREATMENT  
 HYPERGLYCEMIA: INSULIN TREATMENT  
 STEROID REPLACEMENT STRATEGIES  
 THYROID DISEASE

### **GENERAL**

DEALING WITH DIFFICULT PATIENTS AND FAMILIES  
 END OF LIFE DECISIONS  
 ETHICAL GUIDELINES  
 PRESSURE ULCERS  
 ORGAN PROCUREMENT GUIDELINES

### **GASTROINTESTINAL**

ANTIBIOTIC ASSOCIATED COLITIS  
 HEPATIC ENCEPHALOPATHY  
 HEPATIC FAILURE  
 MANAGEMENT OF PATIENTS WITH ASCITES  
 NUTRITIONAL MANAGEMENT  
 ACUTE PANCREATITIS  
 UPPER GI BLEEDING: STRESS PROPHYLAXIS  
 UPPER GI BLEEDING: NON-VARICEAL  
 UPPER GI BLEEDING:VARICEAL

### **HEMATOLOGY**

HEPARIN  
 HEPARIN-INDUCED THROMBOCYTOPENIA  
 THE BLEEDING PATIENT  
 THROMBOCYTOPENIA  
 THROMBOLYTIC THERAPY  
 TRANSFUSION GUIDELINES  
 USE OF HEMATOPOETIC GROWTH FACTORS

WARFARIN

**INFECTIOUS DISEASES**

ACALCULUS CHOLECYSTITIS  
ANTIBIOGRAMS  
BLOODSTREAM INFECTIONS  
CANDIDURIA  
CATHETER RELATED SEPTICEMIA  
CATHETER REPLACEMENT STRATEGIES  
ENDOCARDITIS PROPHYLAXIS  
ENDOCARDITIS DIAGNOSIS AND TREATMENT  
FEBRILE NEUTROPENIA  
FUO  
HIV+ PATIENT INFECTIONS  
MENINGITIS  
NECROTIZING SOFT TISSUE INFECTIONS  
NON-INFECTIOUS CAUSES OF FEVER  
OPHTHALMIC INFECTIONS  
PNEUMONIA, COMMUNITY ACQUIRED  
PNEUMONIA, HOSPITAL ACQUIRED  
SEPTIC SHOCK  
SINUSITIS  
SIRS  
TRANSPLANT INFECTION PROPHYLAXIS  
TRANSPLANT-RELATED INFECTIONS

**NEUROLOGY**

AGITATION, ANXIETY, DEPRESSION & WITHDRAWAL  
BRAIN DEATH  
GUILLAIN-BARRE SYNDROME  
INTRACEREBRAL HEMORRHAGE  
MYASTHENIA GRAVIS  
NEUROMUSCULAR COMPLICATIONS OF CRITICAL ILLNESS  
NON-TRAUMATIC COMA  
SEDATION  
STATUS EPILEPTICUS  
STROKE  
SUB-ARACHNOID HEMORRHAGE

**PHARMACOLOGY**

AMINOGLYCOSIDE DOSING AND THERAPEUTIC MONITORING  
AMPHOTERICIN-B TREATMENT GUIDELINES  
ANALGESIA  
ANTIBIOTIC CLASSIFICATION & COSTS  
DRUG CHANGES WITH RENAL DYSFUNCTION  
PENICILLIN ALLERGY  
NEUROMUSCULAR BLOCKERS  
VANCOMYCIN  
THERAPEUTIC DRUG MONITORING

### **PULMONARY**

ARDS: HEMODYNAMIC MANAGEMENT  
ARDS: STEROID USE  
ARDS: VENTILATOR STRATEGIES  
ASTHMA  
BRONCHODILATOR USE IN VENTILATOR PATIENTS  
BRONCHOSCOPY & THORACENTESIS GUIDELINES  
COPD EXACERBATION & TREATMENT  
CXR (INDICATIONS)  
NONINVASIVE MODES OF VENTILATION  
ENDOTRACHEAL TUBES & TRACHEOTOMY  
TREATMENT OF AIRWAY OBSTRUCTION  
VENTILATOR WEANING PROTOCOL

### **RENAL**

ACUTE RENAL FAILURE :DIAGNOSIS  
ACUTE RENAL FAILURE :MANAGEMENT & TREATMENT  
DIALYSIS  
DIURETIC USE  
HYPERKALEMIA: ETIOLOGY & TREATMENT  
HYPERNATREMIA: ETIOLOGY & TREATMENT  
HYPOKALEMIA: ETIOLOGY & TREATMENT  
HYPONATREMIA: ETIOLOGY & TREATMENT  
OLIGURIA

### **SURGERY**

OBSTETRICAL COMPLICATIONS  
DISSECTING AORTIC ANEURYSM  
POST-OPERATIVE HYPERTENSION  
POST-OPERATIVE MYOCARDIAL ISCHEMIA (NON-CARDIAC  
ARRHYTHMIAS AFTER CARDIAC SURGERY

POST-OPERATIVE BLEEDING  
POST-OPERATIVE MANAGEMENT OF ABDOMINAL  
POST-OPERATIVE MANAGEMENT OF OPEN HEART  
POST-OPERATIVE MANAGEMENT OF THORACOTOMY  
POST-OPERATIVE POWER WEANING  
POST-OPERATIVE MANAGEMENT OF CAROTID  
WOUND HEALING STRATEGIES

### TOXICOLOGY

ACETAMINOPHEN OVERDOSE  
ANAPHYLAXIS  
COCAINE TOXICITY  
ALCOHOL WITHDRAWAL  
HYPERTHERMIA  
LATEX ALLERGY  
UNKNOWN POISONING

### TRAUMA

ABDOMINAL COMPARTMENT SYNDROME  
BLUNT ABDOMINAL INJURY  
BLUNT AORTIC INJURY  
BLUNT CARDIAC INJURY  
DVT PROPHYLAXIS  
EXTREMITY COMPARTMENT SYNDROME  
HEAD INJURY  
HYPOTHERMIA  
IDENTIFICATION OF CERVICAL CORD INJURY  
SPINAL CORD INJURY  
OPEN FRACTURES  
PENETRATING ABDOMINAL INJURY  
PENETRATING CHEST INJURY

1  
2 Referring to **Figure 21**, the acalculous cholecystitis decision support algorithm of  
3 the present invention is illustrated. If an intensivist suspects that acalculous cholecystitis  
4 may be present, the intensivist may not be certain of all of the aspects that would be  
5 indicative of this particular condition. Therefore, the intensivist is lead through a decision  
6 support algorithm, which first causes the intensivist to determine if the patient is clinically  
7 infected, either febrile or leukocytosis 800. If this criteria is not met, the intensivist is

1 prompted that it is unlikely that the patient has acalculous cholecystitis **802**.

2 If the patient is clinically infected **800**, the intensivist is prompted to determine  
3 whether the patient has had a previous cholecystectomy **804**. If patient has had a previous  
4 cholecystectomy, the intensivist is prompted that it is very unlikely that the patient has  
5 acalculous cholecystitis **806**. Alternatively, if a patient has not had a previous  
6 cholecystectomy, the intensivist is prompted to determine whether the patient has any of  
7 seven (7) risk factors, specifically: 1) Prolonged intensive care unit (ICU) stay (defined as  
8 greater than six (6) days); 2) recent surgery (particularly aortic cross clamp procedures); 3)  
9 hypotension; 4) positive end-expiratory pressure (PEEP) greater than ten (10) centimeters  
10 (cm); 5) transfusion greater than six (6) units of blood; 6) inability to use the  
11 gastrointestinal (GI) tract for nutrition; or 7) immunosuppression (AIDS, transplantation,  
12 or leukemia) **808**. If the patient has none of these seven risk factors, the intensivist is  
13 prompted that the patient probably does not have acalculous cholecystitis **810**.

14 If the patient has any of the seven risk factors **808**, the intensivist is prompted to  
15 determine whether the patient has any of the following symptoms: right upper quadrant  
16 (RUQ) tenderness; elevated alkalinephosphatase; elevated bilirubin; or elevated liver  
17 transaminases **812**. If the patient has none of these four (4) symptoms **812**, the intensivist  
18 is prompted to consider other more likely sources of infection (see fever of unknown  
19 origin or FUO) **814**. If the infection remains undiagnosed following an alternative work-  
20 up, the intensivist is prompted to re-enter the algorithm **814**.

21 If the patient has any of these four (4) symptoms **812**, the intensivist is prompted to  
22 determine whether alternative intra-abdominal infectious sources are more likely **816**. If  
23 alternative intra-abdominal infectious sources are not more likely, the intensivist is  
24 prompted to determine whether the patient is sufficiently stable to go for a test **826**. If the  
25 patient is sufficiently stable to go for a test, the intensivist is prompted to perform an mso4  
26 Cholescintigraphy **836**. The normal AC is excluded **838**. If the test indicates an  
27 abnormality, the intensivist is prompted to consider a cholecystectomy or percutaneous  
28 drainage **840**. If the patient is not sufficiently stable to go for a test, the intensivist is  
29 prompted to perform a bedside ultrasound **828**. If no other infectious etiologies are  
30 identified and no abnormalities of the gall-bladder are noted but: a) the patient remains ill  
31 **830**, the intensivist is prompted to consider empiric cholecystostomy **832**. If no other  
32 infectious etiologies are identified and no abnormalities of the gall bladder are noted but:



1       b) the patient is improving **830**, the intensivist is prompted to continue to observe the  
2       patient **834**.

3             If alternative intra-abdominal infectious sources are more likely **816**, the intensivist  
4       is prompted to determine whether the patient is sufficiently stable to go for a test **818**. If  
5       the patient is sufficiently stable to go for a test **818**, the intensivist is prompted to perform  
6       an abdominal CT scan **820**. If no other infectious etiologies are apparent and the test: a)  
7       demonstrates abnormalities of the gall-bladder but not diagnostic; or b) no gall-bladder  
8       abnormalities are noted **822**, the intensivist is prompted to maintain continued observation  
9       of the patient **824**. Alternatively, if this criteria not met **822**, the intensivist is prompted to  
10      perform an mso4 cholescintigraphy **836**. Normal AC is excluded **838**. If the test is  
11      abnormal, the intensivist is prompted to consider cholecystectomy or precutaneous  
12      drainage **840**. If the patient is not sufficiently stable to go for a test, the intensivist is  
13      prompted to perform a bedside ultrasound **828**. If no other infectious etiologies are  
14      identified and no abnormalities of the gall-bladder are noted but: a) the patient remains ill  
15      **830**, the intensivist is prompted to consider empiric cholecystostomy **832**. If no other  
16      infectious etiologies are identified and no abnormalities of the gall bladder are noted but:  
17      b) the patient is improving **830**, the intensivist is prompted to continue to observe the  
18      patient **834**.

19             Referring to **Figure 22**, the adrenal insufficiency decision support algorithm of the  
20      present invention is illustrated. When an intensivist suspects an adrenal problem may be  
21      presented in a patient, the intensivist may initiate the adrenal insufficiency decision  
22      support algorithm which prompts questions concerning all aspects of the condition. First  
23      the intensivist is prompted to determine whether the patient is either hypotensive and/or  
24      has been administered pressors for forty-eight hours or longer **900**. If neither condition is  
25      met, the system advises the intensivist that it is unlikely that an adrenal problem is present  
26      **902**.

27             If one or both conditions are met, the intensivist is asked whether an obvious cause  
28      for hypotensive blood pressure or treatment with pressors are manifested, such as  
29      hypovolemia or low blood volume, myocardial dysfunction, or spinal injury **904**. If at  
30      least one of these obvious causes is present, the intensivist is alerted by the system that the  
31      underlying cause must first be treated **906**. If treatment of a suspected underlying cause is  
32      reversed, yet the hypotension or pressor need persists, the intensivist is further directed to

determine whether other adrenal problems have occurred in the patient's history **908, 910, 912**

In order to examine prior treatment issues, the intensivist is first prompted by the system to determine if the patient has been treated with steroids in the previous six months for at least a two week period **908**. Next, the intensivist is prompted to determine whether the patient has hyponatremia or hyperkalemia **910**. The intensivist is also prompted to determine whether the patient has experienced anticoagulation or become coagulopathic prior to the hypotension or pressor treatment **912**. According to the responses provided by the intensivist to the system queries or blocks **908, 910, and 912**, the system calculates a treatment action **914** as follows: The array of possible responses to diagnosis questions **908, 910, and 912** are given a Decision Code as shown in Table 1: Adrenal Insufficiency Considerations, below.

Table 1: Adrenal Insufficiency Considerations

Question 1 908	Question 2 910	Question 3 912	Decision Code
N	N	N	A
N	N	Y	A
N	Y	N	B
N	Y	Y	C
Y	Y	Y	C
Y	N	N	D
Y	Y	N	B
Y	N	Y	D
Y	Y	Y	C

The possible decision codes of Table 1 are as follows:

Decision Code	Treatment Action
A	Do cosyntropin stim test
B	Consider possible Adrenal Insufficiency. Give decadron 5 mg IV, so cosyntropin stim test and empirically treat with hydrocortione 50 mg IV every 8 hours until stim test results return.
C	Consider possible Adrenal Insufficiency, secondary to adrenal hemorrhage. Give decadron 5 mg IV, so cosyntropin stim test and empirically treat with hydrocortione 50 mg IV every 8 hours until stim test results return.
D	Do cosyntropin stim test, may empirically treat with hydrocortisone 25-50 mg IV every 8 hours until stim test results return

Besides specialized treatment actions listed in the decision codes above, the intensivist is directed to administer a cosyntropin stimulation test 914 in order to see how much cortisone the adrenal gland is producing.

After performing the cosyntropin stimulation test, the intensivist is prompted to enter the patient's level of cortisol before administering cosyntropin and thirty minutes afterwards 916. The software analyzes the test results as follows:

The results in Table 2, shown below, are shown as having certain decision codes A through F.

**Table 2: Cosyntropin Stimulation Test Results**

<b><u>basal (A)</u></b> <b><u>&lt; 15</u></b>	basal (B) 15-20	basal (C) > 25
stim (D) < 5	stim (E) 5-10	stim (F) > 10

Depending upon the outcome of the analysis of Table 2, one of the treatment actions, shown below in Table 3, will be displayed 918.

**Table 3: Cosyntropin Test Result Treatment Actions**

Decision Code	Treatment Action
A + D	<b><u>Adrenal insufficiency diagnosed - treat with hydrocortisone 50 mg IV every 8 hours and consider endocrine consult</u></b>
A + E	Probable Adrenal insufficiency- treat with hydrocortisone 25-50 mg IV every 8

B + D	hours and taper as intercurrent illness improves
A + F	Possible Adrenal insufficiency- consider treatment with hydrocortisone 25 mg IV every 8 hours and taper as intercurrent illness improves
B + E	
A + F	
B + F	
C + E	Adrenal insufficiency unlikely- would not treat
C + F	

1

2 Referring to **Figure 23**, the blunt cardiac injury decision support algorithm of the  
3 present invention is illustrated. If an intensivist suspects that blunt cardiac injury may be  
4 present, the intensivist may not be certain of all aspects that would be critical to or  
5 indicative of this particular condition. Therefore, the intensivist is lead through a decision  
6 support algorithm, which first causes the intensivist to determine whether any of seven (7)  
7 risk factors are present: 1) was thoracic impact greater than fifteen (15) mph; 2) was the  
8 steering wheel deformed; 3) was there precordial ecchymosis, contusions, or abrasions; 4)  
9 was marked precordial tenderness present; 5) was there a fractured sternum; 6) were  
10 bilateral rib/costal cartilage fractures present; 7) were thoracic spine fractures present  
11 **1000**. If none of the 7 risk factors are present, the intensivist is prompted that no further  
12 evaluation is necessary **1002**. If any of the 7 risk factors are present, the intensivist is  
13 prompted to obtain an electrocardiogram (ECG) and chest X-ray (CXR) **1004**.

14 Once the results of the ECG and CXR are obtained, the intensivist is prompted to  
15 determine: whether the ECG results are abnormal, with abnormal being defined as  
16 anything other than sinus rhythm, including ectopy and unexplained sinus tachycardia  
17 (greater than 100 beats/minute); and whether the CXR results are abnormal, with abnormal  
18 being defined as any skeletal or pulmonary injury, especially cardiac enlargement **1006**. If  
19 either the ECG or CXR are not abnormal, the intensivist is prompted that a monitored bed  
20 is unnecessary for the patient **1008**. If either the ECG or CXR are abnormal, the  
21 intensivist is prompted to determine whether there is any hemodynamic instability  
22 (hemodynamic instability being defined as the absence of hypovolemia, spinal cord injury,  
23 or sepsis) that cannot be explained by hypovolemia, spinal cord injury, or sepsis **1010**.

24 If this criteria is not met, the intensivist is prompted: that the patient should be in a  
25 monitored bed; that the ECG should be repeated at 24 hours; that, at any time, if  
26 unexplained hemodynamic instability is present, the intensivist should request a stat echo;  
27 and that, if blunt thoracic aortic injury is also suspected, a transesophageal

1 echocardiogram (TEE) is favored over a transthoracic echocardiogram (TTE) **1012**. Once  
2 the results of these tests are obtained, the intensivist is prompted further to determine  
3 whether ectopy, arrhythmia, or abnormality is present on the ECG **1014**. If none of these  
4 criteria are met, the intensivist is prompted that cardiac injury is excluded **1016**. If any of  
5 these criteria are met, the intensivist is prompted that he should consider monitoring the  
6 patient for an additional 24 hours **1018**.

7 If the internist determines that there is any hemodynamic instability that cannot be  
8 explained by hypovolemia, spinal cord injury, or sepsis **1010**, he is prompted: to perform  
9 a stat echo; and, if blunt thoracic aortic injury is also suspected, that a transesophageal  
10 echocardiogram (TEE) is favored over a transthoracic echocardiogram (TTE) **1020**. Once  
11 the results of the stat echo are obtained, the intensivist is prompted to determine whether  
12 the echo is abnormal with possible causes for the abnormality being: pericardial effusion  
13 (tamponade; hypokineses or akinesis (wall motion); dilatation or reduced systolic  
14 function; acute valvular dysfunction; and/or chamber rupture **1022**. If the stat echo is  
15 abnormal, the intensivist is prompted to treat as indicated for the particular cause of the  
16 abnormality **1026**. If the stat echo is not abnormal, the intensivist is prompted to continue  
17 to monitor the patient and repeat the ECG at 24 hours **1024**.

18 Once the results of the ECG are obtained, the intensivist is prompted to determine  
19 whether ectopy, arrhythmia, or abnormality are present on the ECG **1014**. If this criteria is  
20 not met, the intensivist is prompted that cardiac injury is excluded **1016**. If this criteria is  
21 met, the intensivist is prompted that he should consider monitoring the patient for an  
22 additional 24 hours **1018**.

23 Referring to **Figure 24**, the candiduria decision support algorithm, which is yet  
24 another decision support algorithm of the present invention is illustrated. In the candiduria  
25 decision support algorithm, the intensivist is presented with the criteria for diagnosing  
26 candiduria, or severe fungal infection. First, the intensivist determines whether the patient  
27 has any medical conditions that render the patient prone to fungal infections, such as  
28 diabetes, GU anatomic abnormality, renal transplant, or pyuria **1100**. If there are no such  
29 conditions, the intensivist is next prompted by the system to look for dissemination or  
30 spreading of the fungal infection **1102**. If the infection does not seem to have spread, the  
31 intensivist is prompted to change the patient's catheter and test for pyuria after twenty four  
32 hours have passed **1104**.

1           The intensivist is prompted by the system to determine whether the patient can  
2     have P.O. **1106**. If the patient can take P.O., the system next prompts the intensivist to  
3     determine whether azoles, an organic compound for inhibiting fungal growth, have been  
4     administered in the past three days to fight the infection **1108**. If azoles have been  
5     previously administered, the systemic infection diagnosis is confirmed and the intensivist  
6     is referred to the systemic amphotericin dosing algorithm **1110**. If azoles have not been  
7     previously administered, directions for the proper treatment dosage of fluconazole (a type  
8     of azole) is provided to the intensivist along with adjustments for the species of fungus  
9     found **1112**. Where the patient cannot take P.O., the intensivist is again referred to the  
10    systemic amphotericin dosing algorithm **1114**.

11           When the patient does have some condition prone to fungal infection, the  
12    intensivist is prompted to determine what other signs of dissemination are exhibited in the  
13    patient **1116**. The intensivist is prompted to see if the patient can take P.O. If the patient  
14    cannot take P.O., the intensivist is referred to the systemic amphotericin dosing algorithm  
15    **1120**. If the patient can take P.O., the intensivist is prompted to check whether azoles  
16    have been administered in the previous three days **1122**. If azoles have been administered,  
17    the systemic infection is confirmed and the intensivist is referred to the systemic  
18    amphotericin dosing algorithm **1124**. If no azoles have been administered previously, the  
19    intensivist is given instructions for administering fluconazole to treat the fungal infection  
20    **1126**.

21           If there is no evidence of dissemination, the intensivist is still prompted to  
22    determine whether the patient can take P.O. **1128**. Where the patient cannot take P.O.,  
23    directions are provided to administer amphotericin bladder washing procedures **1130**. If  
24    the patient cannot take P.O., the intensivist is prompted to determine whether azoles have  
25    been administered in the previous three days **1132**. If azoles have been administered, the  
26    systemic infection is confirmed and the intensivist is referred to the systemic amphotericin  
27    dosing algorithm **1134**. If no azoles have been administered previously, the intensivist is  
28    given instructions for administering fluconazole to treat the fungal infection **1136**.

29           Referring to **Figure 25**, the Cervical Spine Injury decision support algorithm of the  
30    present invention is illustrated. If an intensivist suspects that a cervical spine injury may  
31    be present, the intensivist may not be certain of all of the factors that would be indicative  
32    of this particular condition. Therefore, the intensivist is lead through a decision support

1 algorithm, which first prompts the intensivist to determine if the patient is awake, alert, not  
2 intoxicated, and has no mental status changes **1200**. If this criteria is met, the intensivist is  
3 prompted to determine whether the patient has any neck pain **1202**. If the patient does not  
4 have any neck pain, the intensivist is prompted to determine whether the patient has any  
5 other pain which would distract from their neck pain **1204**. If this criteria is not met, the  
6 intensivist is prompted to determine whether the patient has any neurologic deficits **1206**.  
7 If this criteria is not met, the intensivist is prompted that a stable C-spine is present if the  
8 patient can flex, extend, move neck left/right without pain and without neck tenderness to  
9 palpitation **1208**. The intensivist is prompted further that he can remove the collar **1208**.

10 Alternatively, if the patient does have neck pain **1202**, the intensivist is prompted  
11 to order 3 x rays **1210** consisting of: 1) lateral view revealing the base of the occiput to the  
12 upper border of the first thoracic vertebra; 2) anteroposterior view revealing spinous  
13 processes of the second cervical through the first thoracic vertebra; and 3) an open mouth  
14 odontoid view revealing the lateral masses of the first cervical vertebra and entire odontoid  
15 process **1210**. If the x rays are normal the intensivist is prompted to consider extension  
16 then flexion lateral x rays; if normal he is prompted that he can remove the collar; if  
17 abnormal, he is prompted to obtain a surgical consult **1212**. If the x rays are abnormal, the  
18 intensivist is prompted to obtain a surgical consult and order a CT scan **1214**. If the x rays  
19 are indeterminate, the intensivist is prompted to order a CT scan **1216**.

20 Alternatively, if the patient has no other pain which would distract from their neck  
21 pain **1204**, the intensivist is prompted to order 3 x rays (the same types of x rays described  
22 in **1210** above with the same prompting based on normal, abnormal, or indeterminate x  
23 rays) **1218**.

24 If the patient does have neurologic deficits **1206**, the intensivist is prompted to  
25 determine whether the neurologic deficit is referable to the cervical spine **1226**. If this  
26 criteria is not met, the intensivist is prompted to order 3 x rays (the same types of x rays  
27 described in **1210** above with the same prompting based on normal, abnormal, or  
28 indeterminate x rays) **1218**. If the neurologic deficit is referable to the cervical spine  
29 **1226**, the intensivist is prompted that the patient should obtain immediate spine trauma  
30 surgery consult and CT or MRI (if available) **1228**.

31 Alternatively, if the intensivist determines that the patient does not pass the criteria  
32 of being awake, alert, not intoxicated and having no mental status changes **1200**, the

1 intensivist is prompted to determine whether the patient has severe head trauma **1232**. If  
2 this criteria is met, the intensivist is prompted to order CT of the neck with head CT **1236**.

3 If this criteria is not met, the intensivist is prompted to determine whether the patient has  
4 any neurologic deficit referable to the cervical spine **1234**. If the intensivist determines  
5 that the patient does have a neurologic deficit referable to the cervical spine, the intensivist  
6 is prompted that the patient should obtain immediate spine trauma surgery consult and CT  
7 or MRI (if available) **1228**. If the intensivist determines that the patient does not have a  
8 neurologic deficit referable to the cervical spine **1234**, he is prompted to order 3 x rays  
9 (the same types of x rays described in **1210** above with the same prompting based on  
10 normal, abnormal, or indeterminate x rays) **1218**.

11 Referring to **Figure 26**, the Oliguria decision support algorithm of the present  
12 invention is illustrated. If an intensivist suspects that Oliguria may be present, the  
13 intensivist may not be certain of all of the aspects that would be indicative of this  
14 particular condition. Therefore, the intensivist is lead through a decision support  
15 algorithm, which first causes the intensivist to determine if the patient is oliguric, with the  
16 criteria being passage of less than 25 cc of urine in a period of 2 hours **1300**. If this  
17 criteria is met the intensivist is prompted to determine whether the patient is anuric (the  
18 criteria for which is passage of less than 10 cc of urine in a 2 hour period) in spite of fluid  
19 administration **1302**.

20 If this criteria is met, the intensivist is prompted to determine whether the urinary  
21 catheter is working by flushing the catheter **1304**. The intensivist is then prompted to  
22 determine whether the catheter is functioning **1306**. If the catheter is not functioning, the  
23 intensivist is prompted to replace or reposition the catheter **1308**. If the catheter is  
24 functioning, the intensivist is prompted to determine whether the patient has a history of:  
25 1) renal stone disease; 2) abdominal, pelvic, or retroperitoneal cancer; or 3) recent pelvic  
26 or retroperitoneal surgery **1310**. If any of these criteria are met, the intensivist is prompted  
27 to perform the following actions: 1) do renal ultrasound emergently to rule out obstruction;  
28 2) while waiting for ultrasound, administer fluid at the rate of 7-15 ml/kg of bodyweight;  
29 and 3) send urine for specific gravity determination **1312**. Based on the renal ultrasound  
30 test results, the intensivist is prompted to determine whether an obstruction is present  
31 **1314**. If an obstruction is determined to be present, the intensivist is prompted to consult a  
32 urologist immediately **1316**.



1           Alternatively, if the intensivist determines that the patient does not have a history  
2 of: 1) renal stone disease; 2) abdominal, pelvic, or retroperitoneal cancer; or 3) recent  
3 pelvic or retroperitoneal surgery **1310**, the intensivist is prompted to determine whether:  
4 1) the patient has a history of heart failure or known ejection fraction of less than 30  
5 percent; or 2) there are rales on the physical exam **1318**.

6           Alternatively, if following the renal ultrasound test, the intensivist determines that  
7 there is no obstruction the intensivist is prompted to determine whether: 1) the patient has  
8 a history of heart failure or known ejection fraction of less than 30 percent; or 2) there are  
9 rales on the physical exam **1318**.

10           If the intensivist determines that the patient is not anuric **1302**, then the intensivist  
11 is prompted to determine whether: 1) the patient has a history of heart failure or known  
12 ejection fraction of less than 30 percent; or 2) whether there are rales on the physical  
13 examination **1318**. If this criteria is not met, the intensivist is prompted to administer  
14 fluids to the patient at the rate of 10-20 ml/kg of bodyweight **1320** and send the patient's  
15 urine sample for a specific gravity test **1322** as more fully described in **Figure 26A**.

16           Alternatively, if the patient does: 1) have a history of heart failure or known  
17 ejection fraction less than 30 percent; or 2) there are rales on the physical exam **1318**, the  
18 intensivist is prompted to determine whether there has been a chest x-ray (CXR) in the last  
19 6 hours **1324**. If this criteria is not met, the intensivist is prompted to determine whether  
20 there has been a change in respiratory status **1326**. If there has been no change in the  
21 respiratory status, the intensivist is prompted to administer 7-15 ml of fluids per kg of  
22 bodyweight **1328** and to send the patient's urine sample for a specific gravity test.

23           Alternatively, if the intensivist determines that there has been a change in  
24 respiratory status **1326**, the intensivist is prompted to: 1) do a chest x-ray; and 2)  
25 determine whether there is evidence of edema or congestion **1334**. If there is evidence of  
26 edema or congestion **1334**, the intensivist is prompted to: 1) insert a PA catheter to  
27 measure wedge pressure and liver function to direct fluid replacement; and 2) send urine  
28 creatinine and sodium **1332**.

29           If the intensivist determines that there has been a CXR in the last 6 hours **1324**, the  
30 intensivist is prompted to determine whether there is evidence of edema or congestion  
31 **1330**. If there is no evidence of edema or congestion, the intensivist is prompted to

1 administer 7-15 ml of fluids per kg of bodyweight **1328** and send the patient's urine for a  
2 specific gravity test **1322**.

3 Alternatively, if the intensivist determines there is evidence of edema or  
4 congestion **1330**, the intensivist is prompted to: : 1) insert a PA catheter to measure wedge  
5 pressure and liver function to direct fluid replacement; and 2) send urine creatinine and  
6 sodium **1332**.

7 Referring now to **Figure 26A**, the oliguria algorithm description continues.  
8 Following the specific gravity test of the patient's urine, the intensivist is prompted to  
9 determine whether the results indicate the specific gravity is less than 1.018. If this  
10 criteria is met, the intensivist is prompted to: 1) send blood and urine immediately to test  
11 for blood urea nitrogen (BUN), creatinine, electrolytes, and Hgb, and spot urine for  
12 creatinine, sodium, and sediment; and 2) administer 5-10 ml of fluid per kg of bodyweight  
13 **1356**. Once the results of these tests are obtained, the intensivist is prompted to determine  
14 what is the Hgb **1338**.

15 If the Hgb has increased by more than 1.5 gm/dl compared to the previous hgb  
16 **1340**, the intensivist is prompted to: 1) administer fluids 5-10 ml/kg of bodyweight and  
17 follow the urine output closely **1342**. Following this, the intensivist is prompted to  
18 determine whether the labs confirm renal failure by use of the formula  $FE_{Na} = \text{Urine Na} \times$   
19  $\text{Serum Creatinine} / \text{Urine Creatinine} \times \text{Serum Na} \times 100$  **1344**.

20 If the Hgb is within 1.5 gm/dl from the previous hgb or no comparison **1352**, the  
21 intensivist is prompted to determine what is the mean blood pressure **1354**. If the mean  
22 blood pressure is determined to be within 20 percent or higher than the baseline blood  
23 pressure **1356**, the intensivist is prompted to determine whether the labs confirm renal  
24 failure **1344**. If the mean blood pressure is determined to be greater than 20 percent below  
25 the baseline pressure **1358**, the intensivist is prompted to give additional fluids and  
26 consider invasive hemodynamic monitoring **1360**. Following this, the intensivist is  
27 prompted to determine whether the labs confirm renal failure by use of the formula  
28  $FE_{Na} = \text{Urine Na} \times \text{Serum Creatinine} / \text{Urine Creatinine} \times \text{Serum Na} \times 100$  **1344**.

29 Alternatively if the Hgb has decreased by 1.5 gm/dl compared to the previous hgb  
30 **1362**, the intensivist is prompted to: 1) transfuse PRBCs as needed; 2) look for source of  
31 bleeding and check PT, aPTT, & platelet count **1364**. Following this, the intensivist is  
32 prompted to determine what is the mean blood pressure **1354**. If the mean blood pressure

1 is determined to be greater than 20 percent below the baseline pressure **1358**, the  
2 intensivist is prompted to give additional fluids and consider invasive hemodynamic  
3 monitoring **1360**. Following this, the intensivist is prompted to determine whether the labs  
4 confirm renal failure by use of the formula  $FE_{Na} = \text{Urine Na} \times \text{Serum Creatinine} / \text{Urine}$   
5  $\text{Creatinine} \times \text{Serum Na} \times 100$  **1344**.

6 If the labs do not confirm renal failure, as indicated by  $FE_{Na} \leq 1$  percent **1346**, the  
7 intensivist is prompted to: 1) continue to administer fluids and follow urine output; and 2)  
8 recheck creatinine in 6-12 hours **1348**.

9 Alternatively, if the labs do confirm renal failure, as indicated by  $FE_{Na} > 1$  percent  
10 **1350**, the intensivist is prompted to: 1) place central venous pressure (CVP); 2) Assure  
11 adequate intravascular volume; 3) give trial of diuretics: 40 mg lasix IV, if no response in  
12 1 hour, give hydrodiuril 500 mg IV, wait 20-30 minutes then give 100 mg lasix, if  
13 persistent oliguria, restrict: 1) fluids; 2) potassium & phosphate; if diuresis ensues, restrict  
14 only potassium & phosphate; in both situations, adjust all renally excreted medications;  
15 and 4) see acute renal failure **1350**.

16 Referring now to **Figure 26B**, the oliguria algorithm description continues.  
17 Alternatively, following the specific gravity test of the patient's urine, the intensivist is  
18 prompted to determine whether the results indicate the specific gravity is greater than or  
19 equal to 1.018 **1336**. If this criteria is not met **1364**, the intensivist is prompted to  
20 determine whether the urine is dark or tea colored **1366**. If this criteria is met, the  
21 intensivist is prompted to: 1) check creatinine phospho/kinase; and 2) force fluids to  
22 induce diuresis **1368**.

23 If the intensivist determines that the urine is not dark or tea colored, the intensivist  
24 is prompted to: 1) administer 10-20 ml of fluids per kg of bodyweight; and 2) check hgb  
25 **1370**. The intensivist is then prompted to determine what is the hgb **1372**.

26 If the hgb is determined to be greater than 1.5 gm/dl higher than the previous hgb  
27 **1374**, the intensivist is directed to: 1) force fluids; and 2) continue to follow the urine  
28 output **1376**.

29 Alternatively, if the hgb is determined to be within 1.5 gm/dl of the last hgb or  
30 there is no hgb for comparison **1378**, the intensivist is prompted to determine what is the  
31 mean blood pressure **1380**. If the mean blood pressure is determined to be 20 percent or  
32 higher than the baseline pressure **1382**, the intensivist is prompted to: 1) continue to

1 administer fluids; 2) follow urine output; and 3) check creatinine in 6-12 hours **1384**. If  
2 the mean blood pressure is determined to be greater than 20 percent below the baseline  
3 pressure **1386**, the intensivist is prompted to: 1) continue to push fluids; 2) consider  
4 invasive hemodynamic monitoring; and 3) if post-op abdominal trauma, consider  
5 abdominal compartment syndrome **1388**.

6 If the hgb is determined to be greater than 1.5 gm/dl below the previous hgb **1390**,  
7 the intensivist is prompted to: 1) transfuse blood as needed; 2) look for bleeding source; 3)  
8 check PT, aPPT & platelet count; 4) continue to push fluids; and 5) recheck hgb in 1-2  
9 hours **1392**.

10 Referring to **Figure 27**, the open fractures decision support algorithm of the  
11 present invention is illustrated. Open fractures are where bone, cartilage, or a tooth break  
12 and push through the skin surface. The intensivist is first prompted by the system to  
13 determine whether the patient has an open fracture **1500**. If one has occurred, the  
14 intensivist must then determine whether the wound is contaminated with soil, or was  
15 inflicted in a barnyard **1502** in order to address higher risk of infection. If the wound is  
16 contaminated with soil, or was inflicted in a barnyard, the intensivist is prompted to  
17 administer a high dose of penicillin to the antibiotics prescribed **1504**. The intensivist is  
18 also prompted to take several treatment steps **1506**. These treatment steps include  
19 administering tetanus prophylaxis, such an antitoxin injection, monitoring staphylococcus  
20 aureus until twenty-four hours after surgery, caring for the wound within six hours, and  
21 where the injury is found to be more severe during surgery, the intensivist is prompted to  
22 administer aminoglycosides for seventy two hours.

23 If the wound is not contaminated with soil, or was inflicted in a barnyard, the  
24 intensivist is next prompted to determine the severity of the wound **1508**. To do so, the  
25 intensivist must determine the length of the wound and corresponding soft tissue damage.  
26 If the wound is either less than one centimeter and clean or greater than a centimeter long  
27 without extensive soft tissue damage, the Intensivist is prompted to take several treatment  
28 steps **1506** as previously described. Where the soft tissue damage is extensive or  
29 amputation has occurred, the intensivist is prompted by the system to make further  
30 determinations **1510**, **1512**, **1514** about the wound caused by the fracture. The intensivist  
31 is prompted to determine if enough soft tissue coverage is remaining for the wound to  
32 close and heal **1510**, if any arterial repair is needed **1512**, and if extensive soft tissue

1 damage with periosteal injury, and bone exposure **1514**. If there is adequate soft tissue  
2 coverage, the intensivist is advised that risk of infection is low and directed to take  
3 treatment actions **1516**. If arterial damage requiring repair is present, the intensivist is  
4 advised by the system that risk of infection is moderate to high and given treatment  
5 instructions **1518**. Where there is soft tissue injury with periosteal stripping and bone  
6 exposure, the intensivist is alerted by the system that risk of infection is high and given  
7 treatment instructions **1520**. The treatment instructions in each case **1516**, **1518**, **1520**  
8 include administering tetanus prophylaxis, such as antitoxin injection, caring for the  
9 wound within six hours, and performing: monitoring for staphylococcus aureus, and  
10 administering aminoglycosides and high doses of penicillin, all for seventy two hours  
11 before and after any operative procedures.

12 If the intensivist has determined that no exposed fracture has occurred, the system  
13 next prompts the intensivist to determine whether there is any evidence of neuro-vascular  
14 damage **1522**. If there is evidence of neuro-vascular damage, the intensivist is prompted  
15 to consult with a neurosurgeon or vascular surgeon immediately **1524**. If the intensivist  
16 determines there is no evidence of neuro-vascular damage to the patient, the system next  
17 prompts the intensivist to determine whether the patient has compartment syndrome **1526**.  
18 If there is evidence of compartment syndrome seen in the patient, the intensivist is  
19 prompted to consult orthopedics right away **1528**. If there is no evidence of compartment  
20 syndrome seen in the patient, the intensivist is still prompted to consult orthopedics, but  
21 without any prompt for time sensitivity **1530**.

22 Referring to **Figure 28**, the Pancreatitis diagnostic algorithm of the present  
23 invention is illustrated. To evaluate whether a patient has pancreatitis, the intensivist is  
24 first prompted to examine whether severe epigastric abdominal pains and amylase levels  
25 three times greater than normal are present in the patient **1600**. If neither or one of the  
26 conditions is present, the intensivist is prompted to consider other causes of the abdominal  
27 pain, such as mesenteric ischemia, a perforated ulcer, intestinal obstruction, biliary colic,  
28 or an ectopic pregnancy **1602**.

29 If severe epigastric abdominal pains and amylase levels three times greater than  
30 normal are present, the intensivist is next prompted to provide the Ranson Criteria which  
31 is a criteria associated with the severity of pancreatitis and the potential outcome or  
32 prognosis at that particular level of severity, or Apache II score which is also a score

1 associated with the severity of the disease and the potential prognosis at a particular level  
2 of the patient **1604**. If the patient has a Ranson Criteria less than three or an Apache II  
3 score of less than eight, the intensivist is prompted by the system to consider removing the  
4 patient from the Intensive Care Unit **1606**. However, if the patient has a Ranson Criteria  
5 greater than three or an Apache II score of greater than eight, the intensivist is instructed to  
6 perform an abdominal ultrasound test within twenty-four hours **1607**. If the results of the  
7 ultrasound test show a biliary obstruction, the intensivist is instructed to consider  
8 performing an ERCP to find and remove any gallstones **1608**.

9 If the abdominal ultrasound results do not show any biliary obstruction, intensivist  
10 is next prompted to perform more diagnostic tests **1610**. The intensivist is directed to  
11 perform a Dynamic IV contrast and an abdominal Computerized Tomography (CT) scan.

12 If the intensivist does not suspect a surgical condition exists, such as a perforated ulcer,  
13 mesenteric infarction or pancreatic infection, the tests may be performed after three days  
14 have passed. If the intensivist does suspect a surgical condition exists, the tests should be  
15 performed within three days. In either case, if the patient has creatinine levels greater than  
16 or equal to 2 miligrams per dl, the intensivist should not perform the Dynamic IV contrast  
17 test.

18 Once the CT scan is performed, the intensivist is prompted to determine whether  
19 necrotizing pancreatitis is present **1612**. The intensivist is next required to determine  
20 whether the patient has improved since admission **1614**. If no improvement has been  
21 seen, the intensivist is directed to perform percutaneous fluid aspiration and do a gram  
22 stain culture the collected fluid **1616**. If the culture shows infection **1618**, the intensivist is  
23 directed to perform surgical debridement of the pancreas **1620**. If the results of the culture  
24 are sterile **1622**, the intensivist is directed to closely follow up on the patient's condition  
25 **1624** and watch for clinical deterioration **1626**. If the patient does further deteriorate, the  
26 intensivist is then instructed to perform a surgical debridement of the pancreas **1628**. If  
27 the patient does not deteriorate, the intensivist is still prompted to closely follow the  
28 patient's condition **1630**.

29 Where the CT scan does not show signs of necrotizing pancreatitis **1612**, the  
30 intensivist is prompted by the system to closely observe the patient **1632**. The intensivist  
31 is also prompted to check whether clinical deterioration is occurring **1634**. If no  
32 deterioration is observed, the intensivist continues to observe the patient's condition **1636**.

1        If clinical deterioration is occurring **1634**, the intensivist is directed to perform  
2        percutaneous fluid aspiration and do a gram stain culture the collected fluid **1616**. If the  
3        culture shows infection **1618**, the intensivist is directed to order surgical debridement of  
4        the pancreas **1620**. If the results of the culture are sterile **1622**, the intensivist is directed  
5        to closely follow up on the patient's condition **1624** and watch for clinical deterioration  
6        **1626**. If the patient does further deteriorate, the intensivist is then prompted to order a  
7        surgical debridement of the pancreas **1628**. If the patient does not deteriorate, the  
8        intensivist is still directed by the system to closely follow the patient's condition **1630**.

9            Referring to **Figure 29**, the penicillin allergy diagnosis algorithm of the present  
10        invention is illustrated. In order to diagnose a penicillin allergy, the intensivist is first  
11        prompted to determine whether the patient has a history suggestive of previous penicillin  
12        or cephalosporin anaphylaxis **1700**. Various known reactions, including angioedema,  
13        flushing, pruritis, airway obstruction, syncope, and hypertension, are displayed for the  
14        intensivist's review. If the patient has previously had any of these reactions, the  
15        intensivist is prompted to determine whether the patient has ever taken synthetic or  
16        partially synthetic antibiotics, such as ampicillin, amoxicillin, duricef or kefzol, without  
17        any anaphylaxis symptoms **1702**. If the patient has taken synthetics without reaction, the  
18        intensivist is advised by the system that penicillin or cephalosporin may be administered  
19        **1716**. If the patient has reacted to synthetic or partially synthetic antibiotics, the intensivist  
20        is next prompted to determine whether the patient needs penicillin or cephalosporin  
21        specifically **1704**.

22            If the patient is not required to have penicillin or cephalosporin, the intensivist is  
23        prompted to administer the synthetic antibiotics **1706**. If the patient does need penicillin  
24        or cephalosporin, the intensivist is directed by the system to consider consulting with an  
25        allergist or immunologist and perform skin tests for reactions **1708**. Next, the intensivist  
26        is prompted to enter whether the skin test was positive **1710**. If the results are negative,  
27        the intensivist is further directed by the system to administer penicillin or cephalosporin  
28        with caution, to consider pretreatment with benadryl or prednisone to counter any reaction,  
29        and to closely monitor the patient **1712**. If the results of the skin test are positive, the  
30        intensivist is prompted by the system to perform desensitization procedures **1714**.

31            If the patient does not have a history suggestive of previous penicillin or  
32        cephalosporin anaphylaxis **1700**, the intensivist is prompted to determine whether the

1 patient has previously experienced skin-level reactions, such as exfoliative dermatitis,  
2 Stevens Johnson Syndrome, or Toxic Epidermal Necrolysis, when given penicillin or  
3 cephalosporin **1718**. If the patient has previously experienced one of these reactions, the  
4 intensivist is directed by the system to administer an alternative antibiotic **1720**. If the  
5 patient has not experienced one of these reactions, the intensivist is prompted to determine  
6 whether there is a history of any rash when given penicillin or cephalosporin **1722**. If the  
7 patient has not previously had a rash when given penicillin or cephalosporin, the intensivist  
8 is advised that the patient will most likely be able to take penicillin or cephalosporin **1724**.

9 If the patient has previously experienced a rash when given penicillin or  
10 cephalosporin, the intensivist is prompted to determine whether the rash presented when  
11 the patient was given ampicillin or amoxycillin **1726**. If the rash resulted from ampicillin  
12 or amoxycillin, the intensivist is next prompted to determine whether the rash was  
13 urticarial **1728**. If the rash was not urticarial, the intensivist is advised by the system that  
14 the patient probably can take penicillin or cephalosporin, but should be closely monitored  
15 **1730**. If the rash was urticarial, the intensivist is prompted to determine whether or not the  
16 patient needs penicillin or cephalosporin **1704**.

17 If the patient is not required to have penicillin or cephalosporin, the intensivist is  
18 directed by the system to administer the synthetic antibiotics **1706**. If the patient does  
19 need penicillin or cephalosporin, the intensivist is directed to consider consulting with an  
20 allergist or immunologist and perform skin tests for reactions **1708**. Next, the intensivist  
21 is prompted to enter whether the skin test was positive **1710**. If the results are negative,  
22 the intensivist is further directed to administer penicillin or cephalosporin with caution, to  
23 consider pretreatment with benadryl or prednisone to counter any reaction, and to closely  
24 monitor the patient **1712**. If the results of the skin test are positive, the intensivist is  
25 directed to perform desensitization procedures **1714**.

26 Referring to **Figure 30**, the Post-Op Hypertension decision support algorithm of  
27 the present invention is illustrated. If an intensivist determines that there may be a  
28 possibility of post-op hypertension, the intensivist may not be certain of all aspects that  
29 would be involved in this particular condition. Therefore, the intensivist is lead through a  
30 decision support algorithm which prompts the intensivist to determine the appropriate care  
31 to be given.



1 Initially, the intensivist is prompted to determine whether the patient is  
 2 hypertensive (BP greater than 20 percent above mean baseline) **1800**. If this criteria is  
 3 met, the intensivist is prompted to determine whether the patient has any of the causes of  
 4 reversible hypertension: 1) hypercapnia; 2) bladder distension; 3) pain; 4) increased ICP;  
 5 5) drugs (pressors, cocaine, ketamine and chronic MAO use with indirect acting  
 6 vasopressors); 6) automatic hyperreflexia; or 7) volume overload **1802**. If any of these  
 7 criteria are met, the intensivist is prompted to first treat those specific etiologies and, if  
 8 pressure remains high, re-enter algorithm **1804**.

9 Alternatively, if none of these criteria are met **1802**, the intensivist is prompted to  
 10 determine whether the patient is at risk of injury from post-op hypertension (i.e., vascular  
 11 surgery, coronary artery disease, neurosurgery, ocular surgery, etc.) **1806**. If this criteria is  
 12 not met **1806**, the intensivist is prompted to determine whether the BP is greater than 40  
 13 percent above mean baseline **1808**. If this criteria is not met, the intensivist is prompted  
 14 that the patient may not need BP treatment **1810**.

15 If the BP is greater than 40 percent above the mean baseline **1808**, the intensivist is  
 16 prompted to determine whether the patient is in pain **1812**. If this criteria is met **1812**, the  
 17 intensivist is prompted to treat pain and continue **1814**. Following this prompt **1814**, the  
 18 intensivist is prompted next to determine whether the patient is actively bleeding or at  
 19 significant risk for post-op bleeding (i.e., "moist closure" or high drain output) **1816**. If  
 20 this criteria is met **1816**, the intensivist is prompted to use only short acting agents  
 21 including emolol and nitroprusside as needed until bleeding has abated **1818**.

22 Alternatively, if this criteria is not met **1816**, the intensivist is prompted to  
 23 determine whether the patient is tachycardic (absolute greater than 90 bpm or ((relative  
 24 greater than 15 percent over baseline)) **1820**. If this criteria is met **1820**, the intensivist is  
 25 prompted to go to Decision Table C, which is programmed for the condition of a high  
 26 heart rate. If this criteria is not met **1820**, the intensivist is prompted to eliminate (NOT C)  
 27 Table C and proceed to the next decision point **1820**.

<u>HR↑Table C</u>							
	CAD	Y	Y	Y	N	N	N
	RAD	N	Y	Y	N	Y	N

	↓EF	N	N	Y	N	Y	Y
Treatment	1 <sup>ST</sup>	L	E	L	L	A	E
	2 <sup>ND</sup>	E	L	A	N	N	A

The intensivist is prompted next to determine whether the patient is bradycardic (absolute less than 60 bpm) **1822**. If this criteria is met, the intensivist is prompted to go to Decision Table B, which is programmed for the condition of a low heart rate.

HR ↓ Table B							
	CAD	Y	Y	Y	N	N	N
	RAD	N	Y	Y	N	Y	N
	↓EF	N	N	Y	N	Y	Y
Treatment	1 <sup>ST</sup>	N	N	A	N	A	A
	2 <sup>ND</sup>	S	S	S	H	H	H

If this criteria is not met, the intensivist is prompted to eliminate (NOT B) Table B and proceed to the next decision point **1822**. [Note: If NOT C and NOT B, the intensivist is prompted to go to Table A by default, i.e., If NOT C and NOT B Then A].

HR (nl) Table A							
	CAD	Y	Y	Y	N	N	N
	RAD	N	Y	Y	N	Y	N
	↓EF	N	N	Y	N	Y	Y
Treatment	1 <sup>ST</sup>	L	E	A	N	A	A
	2 <sup>ND</sup>	N	N	E	A	N	N

The intensivist is prompted next to determine, sequentially, table input values for CAD, RAD, and EF.

In these decision tables, the letter references have the following meanings:

L=labetalol, E=esmolol, A=enalapril, N=nicardipine, H=hydralazine, S=nitroprusside.

1 The reference to 1<sup>st</sup> and 2<sup>nd</sup> means that treatment should begin with the 1<sup>st</sup> drug and add or  
2 substitute the 2<sup>nd</sup> drug as needed.

3 Using the above decision tables, the intensivist is prompted to determine whether  
4 the patient has known coronary artery disease (CAD) or 3 or more risk factors for CAD  
5 **1824**. If this criteria is met **1824**, the intensivist is prompted to enter a “Y” or “YES” for  
6 CAD into the table selected above in **1820** and **1822**. If this criteria is not met, the  
7 intensivist is prompted to enter a “N” or “NO” for CAD into the table selected above in  
8 **1820** and **1822**.

9 Next, the intensivist is prompted to determine whether the patient has known  
10 reactive airway disease (RAD)**1826**. If this criteria is met **1826**, the intensivist is  
11 prompted to enter a “Y” or “YES” for RAD into the table selected above in **1820** and  
12 **1822**. If this criteria is not met, the intensivist is prompted to enter a “N” or “NO” for  
13 RAD into the table selected above in **1820** and **1822**.

14 Next, the intensivist is prompted to determine whether the patient has known EF  
15 less than 30 percent or a history of systolic heart failure **1828**. If this criteria is met **1828**,  
16 the intensivist is prompted to enter a “Y” or “YES” for EF into the table selected above in  
17 **1820** and **1822**. If this criteria is not met **1828**, the intensivist is prompted to enter a “N”  
18 or “NO” for EF into the table selected above in **1820** and **1822**.

19 Based on the table selected in **1820** and **1822** above, and the table inputs  
20 determined from **1824**, **1826**, and **1828**, the intensivist is prompted with the proper  
21 medication to administer for the 1<sup>st</sup> and 2<sup>nd</sup> treatment.

22 If the patient is not in pain **1812**, the intensivist is prompted to employ the  
23 procedures described above in **1816**.

24 If the patient is at risk of injury from post-op hypertension **1806**, the intensivist is  
25 prompted to determine whether the blood pressure is greater than 40 percent above  
26 baseline **1830**. If this criteria is met **1830**, the intensivist is prompted to employ the  
27 procedures described above in **1812**.

28 Alternatively, if this criteria is not met **1830**, the intensivist is prompted to  
29 determine whether the patient is in pain **1836**. If this criteria is met **1836**, the intensivist is  
30 prompted to treat pain and reevaluate following analgesia and, if still hypertensive, to  
31 continue algorithm **1838**. Following this action **1838**, the intensivist is prompted to

1 employ the procedures described above in **1816**. If the patient is not in pain **1836**, the  
2 intensivist is prompted to employ the procedures described above in **1816**.

3 If the patient is determined not to be hypertensive **1800**, the intensivist is prompted  
4 to determine whether the patient requires their BP controlled near baseline (i.e.,  
5 neurosurgery, carotid surgery, thoracic aorta surgery) **1832**. If this criteria is not met  
6 **1832**, the intensivist is prompted that the patient probably does not need treatment **1834**.

7 Alternatively, if this criteria is met **1832**, the intensivist is prompted to employ the  
8 procedures described above in **1836**.

9 Referring to **Figure 31**, the pulmonary embolism diagnosis algorithm is illustrated.  
10 If a pulmonary embolism is suspected, the intensivist is first prompted to determine  
11 whether the patient is hemodynamically unstable **2900**. If the patient is hemodynamically  
12 unstable, the intensivist is directed by the system to consider performing an immediate  
13 transthoracic echocardiogram, pulmonary angiogram and treatment consistent with  
14 massive pulmonary embolism **2902**. If the patient is not hemodynamically unstable, the  
15 intensivist is prompted to perform a VQ scan and perform further assessment of the patient  
16 **2904**.

17 In order to further assess the patient, the intensivist is prompted to respond to a  
18 series of questions **2906**, **2908**, **2910**, **2912**. The intensivist is prompted to determine  
19 whether any of the following patient conditions are present: Dyspnea, Worsening chronic  
20 dyspnea, Pleuritic chest pain, Chest pain that is non- retro sternal & non- pleuritic, O<sub>2</sub>  
21 saturation < 92% on room air that corrects with 40% O<sub>2</sub> supplementation, Hemoptysis, or  
22 Pleural rub **2906**. The intensivist is also prompted to determine whether any risk factors  
23 are in the patient's history, such as: Surgery within 12 weeks, Immobilization (complete  
24 bed rest) for > 3 days within 4 weeks, Previous DVT or objectively diagnosed PE, Lower  
25 extremity fracture & immobilization within 12 weeks, Strong family history of DVT or  
26 PE ( $\geq 2$  family members with objective proven events or 1<sup>st</sup> degree relative with  
27 hereditary thrombophilia), Cancer (treatment within the last 6 months or palliative stages),  
28 Postpartum, or Lower extremity paralysis **2908**. Further, the intensivist must determine  
29 whether the patient has any of the following symptoms: Heart rate > 90 beats/min, Temp  
30  $\geq 38.0$ , CXR free of abnormalities (edema, pneumonia, pneumothorax), or Leg symptoms  
31 c/w DVT, syncope, blood pressure less than 90 mm Hg with heart rate greater than 100  
32 beats/min, receiving mechanical ventilation and/or oxygen supplementation greater than

1 40%, and new onset or right heart failure (-JVP, new S1, Q3, T3, or RBBB) **2910**. The  
2 intensivist is also queried by the system to consider alternative diagnosis that may be more  
3 likely than pulmonary embolism. To do so, the intensivist is prompted to consider  
4 conditions that simulate major pulmonary embolism, such as myocardial infarction, acute  
5 infection with COPD, septic Shock, dissecting aortic aneurysm, or occult hemorrhage.  
6 The intensivist is additionally prompted to consider conditions that simulate minor  
7 pulmonary embolism, such as acute bronchitis, pericarditis, viral pleurisy, pneumonia, and  
8 esophageal spasm **2912**.

9 Referring to **Figure 31A**, the pulmonary embolism algorithm description  
10 continues. The intensivist enters the answers to the assessment queries posed **2906**, **2908**,  
11 **2910**, **2912** into the system. If two or more responses to the patient condition query **2906**  
12 were answered yes and one or more questions were answered yes from: Heart rate > 90  
13 beats/min, Temp  $\geq 38.0$ , CXR free of abnormalities, or Leg symptoms c/w DVT of the  
14 symptoms query **2910**, the intensivist is informed that a typical pulmonary embolism is  
15 present **2914**. Next, the system compares this response to the answer to the alternative  
16 diagnosis query **2912**. If an alternative diagnosis is at least as likely as pulmonary  
17 embolism **2916**, the intensivist is also given a low probability **2918** to moderate  
18 probability **2920** risk factor. If an alternative diagnosis is less likely than pulmonary  
19 embolism **2922**, the intensivist is given a moderate **2924** to high **2926** probability risk  
20 factor.

21 If less than two yes answers resulted from the patient conditions **2906**, the  
22 intensivist is advised by the system that an atypical pulmonary embolism may be present  
23 **2928**. Next, the system compares this response to the answer to the alternative diagnosis  
24 query **2912**. If an alternative diagnosis is at least as likely as pulmonary embolism **2930**,  
25 the intensivist is told there is no risk and low probability **2932** or some risk with a low  
26 probability **2934** risk factor. If an alternative diagnosis is less likely than pulmonary  
27 embolism **2934**, the intensivist is given a no risk and low probability **2938** to risk but  
28 moderate probability **2940**.

29 If at least one answer to the symptoms of syncope, blood pressure less than 90 mm  
30 Hg with heart rate greater than 100 beats/min, receiving mechanical ventilation and/or  
31 oxygen supplementation greater than 40%, and new onset or right heart failure **2910** is  
32 yes, the intensivist is prompted with a message that severe pulmonary embolism is

occurring **2942**. Next, the system compares this response to the answer to the alternative diagnosis query **2912**. If an alternative diagnosis is at least as likely as pulmonary embolism **2944**, the intensivist is told there is a moderate probability of pulmonary embolism **2946**. If an alternative diagnosis is less likely than pulmonary embolism **2948**, the intensivist is notified that a high probability of pulmonary embolism is present **2950**.

Once the risk factors and probabilities are determined the system compares this information to the VQ scan results. This comparison is performed according to the following Table 4 below.

**Table 4: Probability table**

<u>Input</u>	<u>Clinical Probability</u>		
<u>V/Q Scan</u>	High	Moderate	Low
High	A	A	B
Intermediate	B	C	C
Low	B	C	E
Normal	E	E	E

Where the VQ scan column and the risk column intersect, a letter code is assigned to various treatment instructions. The treatment instructions are as follows.

A = Pulmonary embolus diagnosed. Begin treatment

E = Pulmonary embolus excluded

B = Proceed with the following work-up:

- 1) Perform spiral CT(If patient has renal insufficiency [creatinine > 2.0], consider going directly to pulmonary angiogram to reduce the potential dye load). If positive begin treatment,
- 2) If negative, assess for DVT using compression ultrasound or venography. If positive begin treatment,
- 3) If negative, perform pulmonary angiogram. If positive begin treatment, if negative diagnosis excluded.

1 C = Proceed with the following work-up:

- 2 1) Perform spiral CT. If positive begin treatment,  
3 2) If negative, assess for DVT using compression ultrasound or venography. If  
4 positive begin treatment,  
5 3) If negative perform D-dimer assay(elisa only). If negative diagnosis  
6 excluded, If positive, perform serial ultrasound of the lower extremities.

7 Once the correlation is made, the instructions associated with the letter code are displayed  
8 by the system to prompt the intensivist with diagnosis and treatment instructions.

9 Referring to **Figure 32**, the seizure decision support algorithm of the present  
10 invention is illustrated. If an intensivist encounters seizure in a patient, he may not be  
11 certain of all of the aspects and the timelines that are critical to treating this particular  
12 condition. Therefore, the intensivist is lead through a decision support algorithm, which  
13 divides the treatment sequence into three segments: 0-30 minutes; 30-60 minutes; and  
14 beyond 60 minutes.

15 At the onset of a seizure, in the 0-30 minute segment of the algorithm, the  
16 intensivist is prompted to give the patient lorazepam (0.1 mg/kg of bodyweight) in 2 mg  
17 boluses up to 8 mg **2000**. Subsequently, the intensivist is prompted to give the patient  
18 phenytoin (18-20 mg/kg of bodyweight) at 50mg/min of fosphenytoin (18-20 mg/kg of  
19 bodyweight) at 150 mg/min followed by 5 mg/kg of bodyweight/day through separate IV  
20 line **2002**.

21 During the 30-60 minute segment of the algorithm, the intensivist is prompted to:  
22 reload additional phenytoin or fosphenytoin (10 mg/kg of bodyweight) maintaining  
23 previous infusion; and give additional lorazepam (0.05 mg/kg of bodyweight) **2004**.  
24 Subsequently, the intensivist is prompted to begin continuous EEG monitoring **2006**.

25 The intensivist is then prompted to determine whether the patient is  
26 hemodynamically stable **2008**. If hemodynamically stable, the intensivist is prompted to  
27 administer propofol 1-2 mg/kg of bodyweight bolus followed by 2-10 mg/kg/hr **2010**.

28 At the 60 minute segment of the algorithm, the intensivist is prompted that if  
29 seizure activity stops, he should taper either midazolam or propofol over the next 12-24  
30 hours while maintaining phenytoin but if seizures persist, he is prompted to move to the  
31 pentobarbital coma block **2012**.

32 Under pentobarbital coma, the intensivist is prompted to administer 10-15

1 mg/kg/hr and to maintain until seizure control is achieved on EEG 2014. The intensivist is  
2 prompted further that the patient usually requires PA catheter and pressors to maintain  
3 hemodynamic control **2014**.

4 Alternatively, if the patient is determined to be hemodynamically unstable **2016**,  
5 the intensivist is prompted to utilize fluids and pressors as needed (phynylephrine or  
6 dopamine) midazolam 0.2 mg/kg bolus followed by 0.1-2.0 mg/kg/hr **2018**.

7 At the 60 minute segment of the algorithm, the intensivist is prompted that if  
8 seizure activity stops, he should taper either midazolam or propofol over the next 12-24  
9 hours while maintain phenytoin but if seizures persist, he is prompted to move to the  
10 pentobarbital coma block **2012**.

11 Under pentobarbital coma, the intensivist is prompted to administer 10-15  
12 mg/kg/hr and to maintain until seizure control is achieved on EEG 2014. The intensivist is  
13 prompted further that the patient usually requires PA catheter and pressors to maintain  
14 hemodynamic control **2014**.

15 Referring to **Figure 33**, the supra ventricular tachycardia (SVT) decision support  
16 algorithm of the present invention is illustrated. If an intensivist determines that SVT is  
17 present, the intensivist may not be certain of all aspects that would be involved in treating  
18 this particular condition. Therefore, the intensivist is lead through a decision support  
19 algorithm which prompts the intensivist to determine the appropriate care to be given.

20 Initially, the intensivist is prompted to determine whether SVT is stable or unstable  
21 **2100**. If SVT is stable **2102**, the intensivist is prompted to determine whether the patient  
22 has a regular or irregular rhythm **2102**. If the patient has a regular rhythm **2104**, the  
23 intensivist is prompted to determine whether there is a wide complex or a narrow complex  
24 **2104**. If the intensivist determines that there is a wide complex **2106**, the intensivist is  
25 prompted to administer adenosine 6 mg/12 mg (if needed) **2108**. Following the  
26 administering of adenosine **2108**, the intensivist is prompted to consider that if the patient  
27 converts to sinus rhythm (SR) to – consider re-entrant junctional or WPW re-entrant. If  
28 the wide complex recurs, treat the patient with esmolol or Ca+2 blockers.

29 Alternatively; if no effect, the intensivist is prompted to consider V-tach **2112**.  
30 Next, the intensivist is prompted to: 1) load procainamide 150 mg over 10 min, then 1  
31 mg/min infusion; and 2) synchronized cardiovert **2114**.

32 Alternatively, if the wide complex slows, the intensivist is prompted to consider



1 SVT w/ aberrancy and continue to slow with esmolol or Ca+2 blockers **2116**.

2 The intensivist is prompted next to administer esmolol/calcium blockers and link to  
3 ventricular rate control **2118**. The intensivist is prompted next to determine whether there  
4 has been a conversion to SR **2120**. If there is no conversion to SR in 24 hours, the  
5 intensivist is prompted to add antiarrhythmic agent and consider anticoagulation **2122**.  
6 The intensivist is prompted next to determine whether there has been conversion to SR. If  
7 conversion to SR, the intensivist is prompted to continue maintenance antiarrhythmic  
8 agent during hospitalization **2124**. If no conversion to SR, the intensivist is prompted to  
9 cardiovert while on antiarrhythmic & following heparinization **2126**.

10 If the patient has a regular rhythm **2104**, the intensivist is prompted to determine  
11 whether there is a wide complex or a narrow complex **2104**. If the intensivist determines  
12 that there is a narrow complex **2128**, the intensivist is prompted to administer adenosine  
13 6mg/12mg (if needed) **2130**. If administering the adenosine **2130** slows the ventricular  
14 rate only and the atrial rate persists, the intensivist is prompted to consider atrial flutter  
15 and continue to slow with esmolol or Ca+2 blockers **2132**. The intensivist is prompted  
16 next to employ the procedures described above in **2118**.

17 If administering the adenosine **2130** converts the patient to SR, the intensivist is  
18 prompted to consider re-entrant sinus or junctional and if recurs, treat with esmolol or  
19 Ca+2 blockers **2134**.

20 If administering the adenosine **2130** slows both atrial and ventricular rates the  
21 intensivist is prompted that there is a probable sinus tachycardia **2136**. The intensivist is  
22 prompted next to continue to slow with esmolol **2138**. The intensivist is prompted next to  
23 employ the procedures described above in **2118**.

24 If SVT is stable **2102**, the intensivist is also prompted to determine whether the  
25 patient has a regular or irregular rhythm **2102**. If the patient has an irregular rhythm **2140**,  
26 the intensivist is prompted that if no p waves, there is probable Atrial fibrillation **2142**.  
27 The intensivist is prompted next to slow ventricular response with esmolol or Ca+2  
28 blockers **2144**. The intensivist is prompted next to employ the procedures described above  
29 in **2118**.

30 If the patient has an irregular rhythm **2140**, the intensivist is prompted to determine  
31 whether there are more than 3 p wave types MAT – and to treat underlying lung dz. and  
32 avoid theophylline compounds **2146**. The intensivist is prompted next to slow rate with

1 Ca+2 blockers only **2148**. The intensivist is prompted next to employ the procedures  
2 described above in **2118**.

3 Referring now to **Fig. 33A**, the description of the SVT decision algorithm  
4 continues. If SVT is unstable **2101**, the intensivist is prompted to determine whether the  
5 patient has SBP less than 80, ischemia, mental status changes **2150**. The intensivist is  
6 prompted next to perform synchronous cardioversion (100 J, 200 J, 300 J) **2152**. The  
7 intensivist is prompted next that if sinus rhythm: 1) correct reversible etiologies; 2)  
8 consider starting IV antiarrhythmic for maintenance of sinus rhythm **2154**. Alternatively,  
9 following **2152**, the intensivist is prompted next that if continued SVT: 1) correct  
10 reversible etiologies; 2) load IV antiarrhythmic (see dosing guidelines) and repeat DC  
11 cardioversion **2156**.

12 For example, and without limitations, wide complex QRS Tachycardia is also  
13 addressed in the decision support algorithm of the present invention. Referring to **Figure**  
14 **34**, the wide complex QRS tachycardia decision support algorithm is illustrated. If an  
15 intensivist determines that there may be a possibility of wide complex QRS tachycardia,  
16 the intensivist may not be certain of all aspects that would be involved in this particular  
17 condition. Therefore, the intensivist is lead through a decision support algorithm which  
18 prompts the intensivist to determine the appropriate care to be given.

19 Initially, the intensivist is prompted to determine whether the patient is  
20 hemodynamically stable (no angina, heart failure, or hypotension (systolic less than 80  
21 mm)) **2200**. If this criteria is not met, the intensivist is prompted to go to the cardio-  
22 pulmonary guidelines algorithm which is generally known to those skilled in the art.

23 Alternatively, if this criteria is met, the intensivist is prompted to determine  
24 whether the patient is within 7 days of a myocardial infarction or at risk for myocardial  
25 ischemia **2202**. If the patient is not within 7 days of a myocardial infarction or at risk for  
26 myocardial ischemia **2202**, the intensivist is prompted to determine whether the wide  
27 complex QRS rhythm is sustained (greater than 30 seconds) **2234**. If this criteria is not  
28 met, the intensivist is prompted to determined whether the QRS is monomorphic **2236**. If  
29 the QRS is monomorphic **2236**, the intensivist is prompted to determine whether the  
30 patient has structural heart disease **2242**. If the patient has structural heart disease **2242**,  
31 the intensivist is prompted to: 1) monitor closely; 2) look for reversible etiologies; and 3)  
32 consider antiarrhythmic therapy **2244**. If the patient does not have structural heart disease

1       **2242**, the intensivist is prompted to: 1) monitor closely; 2) look for reversible etiologies;  
2       and 3) if recurs and symptomatic may require further testing (prolonged holter or EP  
3       study) **2246**.

4             If the QRS is not monomorphic **2236**, the intensivist is prompted to determine  
5       whether the QT is prolonged **2238**. If this criteria is met, the intensivist is prompted to: 1)  
6       check K; 2) give Mg; and 3) consider overdrive pacing **2240**. If the intensivist determines  
7       that the QT is not prolonged, **2238**, the intensivist is prompted to employ the procedures  
8       described above in **2242**.

9             If the wide complex QRS rhythm is sustained **2234**, the intensivist is prompted to  
10      determine whether the rhythm is polymorphic or irregular **2208**. If the rhythm is  
11      polymorphic or irregular, the intensivist is prompted to consider atrial fibrillation with  
12      accessory pathway conduction and load with procainamide and get a cardiology  
13      consultation **2210**. If the rhythm is not polymorphic or irregular, the intensivist is  
14      prompted with the question of whether he wishes to: 1) perform ECG diagnosis; or 2)  
15      administer adenosine diagnostically **2220**. If the intensivist makes the determination to  
16      perform an ECG diagnosis **2220**, he is prompted to go to the ECG diagnosis algorithm  
17      **2300**.

18            If the intensivist makes the determination to administer adenosine diagnostically  
19      **2220**, he is prompted to go to the administer adenosine branch of the algorithm **2222**. If  
20      there is no effect, the intensivist is prompted that there is probable VT and to determine  
21      whether the VT is monomorphic **2224**. If the VT is monomorphic **2224**, the intensivist is  
22      prompted to load with procainamide and perform synchronous cardioversion **2226**.

23            Alternatively, if the VT is not monomorphic **2224**, the intensivist is prompted to  
24      load with lidocaine and perform immediate cardioversion **2228**.

25            If the ventricular response is slowed after administering adenosine **2222**, the  
26      intensivist is prompted to consider SVT with aberrancy and treat with esmolol or Ca  
27      blockers **2230**.

28            If the ventricular response converts to sinus rhythm after administering adenosine  
29      **2222**, the intensivist is prompted: to consider re-entrant mechanism with BBB or WPW;  
30      and, 1) if WPW consult cardiology for possible ablation **2232**.

31            If the patient is within 7 days of a myocardial infarction or at risk for myocardial  
32      ischemia **2202**, the intensivist is prompted to determine whether the wide complex is

1       sustained (30 seconds) **2204**. If the wide complex is not sustained **2204**, the intensivist is  
2       prompted to determine whether the patient: 1) symptomatic; 2) tachycardia runs are  
3       frequent; or 3) the tachycardia rates are rapid (greater than 180) **2212**. If this criteria is not  
4       met, the intensivist is prompted to observe **2216**. Alternatively, if this criteria is met **2212**,  
5       the intensivist is prompted to: 1) administer lidocaine 100-200 mg & 1-4 mg/min  
6       infusion; and 2) amiodarone **2214**.

7             If the wide complex is sustained **2204**, the intensivist is prompted to determine  
8       whether the rate is greater than 140/min **2206**. If this criteria is not met **2206**, the  
9       intensivist is prompted: to consider accelerated idioventricular, and that in some patients  
10      this can lead to hemodynamic compromise; and that 1) he can perform overdrive pacing if  
11      needed **2218**.

12            Alternatively, if this criteria is met, the intensivist is prompted to follow the  
13      procedures in **2208**.

14            If the intensivist makes the determination to perform ECG Diagnosis **2220**, he is  
15      prompted to go to the ECG Diagnosis branch of the algorithm **2220**. Referring now to  
16      Figure 34A, in the ECG Diagnosis branch, the intensivist is prompted to determine  
17      whether the patient has known pre-excitation syndrome **2300**. If this criteria is met, the  
18      intensivist is prompted to determine whether the QRS complexes are predominantly  
19      negative in leads V4-V6 **2302**. If the QRS complexes are predominantly negative in leads  
20      V4-V6, the intensivist is prompted that there is probable VT **2304**.

21            If the QRS complexes are not predominantly negative in leads V4-V6 **2302**, the  
22      intensivist is prompted to determine whether there is a QR complex in one or more of  
23      leads V2-V6 **2306**. If this criteria is met, the intensivist is prompted that there is probable  
24      VT **2308**.

25            Alternatively, if this criteria is not met **2306**, the intensivist is prompted to  
26      determine whether there are more QRS complexes than P waves **2310**. If there are more  
27      QRS complexes than P waves **2310**, the intensivist is prompted that there is probable VT  
28      **2312**. If there are not more QRS complexes than P waves **2310**, the intensivist is  
29      prompted: to consider pre-excited SVT; and that he may wish to perform EP study **2314**.

30            If the intensivist determines that the patient does not have known pre-excitation  
31      syndrome **2300**, the intensivist is prompted to determine whether there is an RS complex  
32      present in any precordial lead **2316**. If this criteria is not met **2316**, the intensivist is

1 prompted that there is probable VT **2318**.

2 Alternatively, if this criteria is met **2316**, the intensivist is prompted to determine  
3 whether the R to S interval is greater than 100 MS in any one precordial lead **2320**. If this  
4 criteria is met, the intensivist is prompted that there is probable VT **2322**.

5 If the R to S interval is not greater than 100 MS in any one precordial lead **2320**,  
6 the intensivist is prompted to determine whether there is evidence of atrioventricular  
7 dissociation **2324**. If this criteria is met, the intensivist is prompted that there is probable  
8 VT **2326**.

9 Alternatively, if there is no evidence of atrioventricular dissociation **2324**, the  
10 intensivist is prompted to determine whether V-1 is negative and V-6 positive and QRS  
11 greater than 0.14 mSEC **2328**. If this criteria is met, the intensivist is prompted that there  
12 is probable VT **2330**.

13 If this criteria is not met **2328**, the intensivist is prompted that the situation may  
14 represent SVT with aberrancy or underlying bundle branch block **2332**.

15 Referring to **Figure 35**, the assessment of sedation algorithm of the present  
16 invention is illustrated. If an intensivist encounters a need for sedation, he may not be  
17 certain of all of the aspects and the timelines that are critical to this particular process.  
18 Therefore, the intensivist is lead through a decision support algorithm, which prompts the  
19 intensivist to address a number of factors in the process **3100**.

20 The intensivist is prompted initially to go to the Scoring section of the algorithm  
21 **3100**. The intensivist is prompted to proceed through a number of scorings **3102** and to  
22 first score the patient's alertness with points being allocated in the following manner:  
23 asleep/unresponsive=0; responsive to voice=1; and hyperresponsive=2 **3104**.

24 The intensivist is prompted next to score the patient's movement with points being  
25 allocated in the following manner: no spontaneous movement=0; spontaneous  
26 movement=1; and pulls at lines, tubes, dressings=2 **3106**.

27 The intensivist is prompted next to score the patient's respiration based on whether  
28 the patient is mechanically ventilated or spontaneously breathing with points being  
29 allocated as subsequently discussed. If the patient is mechanically ventilated, the  
30 intensivist is prompted to allocate points in the following manner: no spontaneous  
31 ventilation=0; spontaneous ventilations and synchronous with ventilator=1; or  
32 spontaneous ventilations with cough or dysynchrony>10 percent of breaths=2 **3108**.

1 Alternatively, if the patient is spontaneously breathing, the intensivist is prompted to  
2 allocate points in the following manner: respiration rate (RR) <10=0; RR=10-30=1; or  
3 RR>30=2 **3108**.

4 The intensivist is prompted next to score the patient's heart rate with points being  
5 allocated in the following manner: >20 percent below mean for last 4 hr=0; within 20  
6 percent mean for last 4 hr=1; or >20 percent above mean for last 4 hr=2 **3110**.

7 The intensivist is prompted next to score the patient's blood pressure with points  
8 being allocated in the following manner: MAP >20 percent for last 4 hr=0; MAP within  
9 20 percent mean for last 4 hr=1; or MAP >20 percent above mean for last 4 hr=2 **3112**.

10 The intensivist is prompted next to determine the sedation score by the following  
11 formula: SEDATION SCORE=alertness + movement + respirations + heart rate + blood  
12 pressure **3114**. In one embodiment, respiratory rate, heart rate, and BP can be computer  
13 linked to monitor data thereby simplifying the sedation scoring assessment. The nursing  
14 observations are deemed intuitive and the nursing burden in sedation scoring can be  
15 minimal by using this point scoring.

16 Referring now to **Figure 35A**, the sedation assessment algorithm description  
17 continues. The intensivist is prompted then to continue the sedation assessment by  
18 moving to the Pain Assessment section of the algorithm **3116**.

19 In the Pain Assessment section, the intensivist is prompted to determine whether  
20 the patient is conscious, communicative, and acknowledging pain **3118**. If this criteria is  
21 not met, the intensivist is prompted to determine: whether the sedation score is greater  
22 than 2 and the patient: is known to be in pain before becoming uncommunicative; or S/p  
23 recent surgery; or having tissue ischemia or infarct; or has wounds; or has large tumor  
24 possibly impinging on nerves. If the answer to either of these two questions is YES, the  
25 intensivist is prompted to treat for pain **3118**. The intensivist is prompted then to  
26 continue the assessment by moving to the Delirium Assessment section of the algorithm  
27 **3118**.

28 In the Delirium Assessment section, the intensivist is prompted to determine  
29 whether the sedation score is greater than 2 AND the patient has: day/night reversal with  
30 increased agitation at night OR eyes open and "awake" but disoriented; or eyes open and  
31 "awake" but pulling at lines, tubes, or dressings OR difficult to sedate prior to ventilator

1 weaning OR paradoxical response to benzodiazepines. If this criteria is met, the  
2 intensivist is prompted to consider butyrophenone **3120**.

3 Referring to **Figure 36**, the Bolus sliding scale algorithm is illustrated. If an  
4 intensivist encounters a need for sedation, the algorithm for which may contain a reference  
5 to the bolus sliding scale for midazolam, he may not be certain of all of the aspects which  
6 are critical to this scale. Therefore, the intensivist is lead through a decision support  
7 algorithm, which prompts the intensivist through the use of the scale **3200**.

8 If lorazepam is less than 0-2 mg IV q 6hr, then the intensivist is prompted to give  
9 midazolam 1-2 mg q 5 min until adequately sedated **3202**.

10 Alternatively, if lorazepam equals 2-4 mg IV q 4 hr, then the intensivist is  
11 prompted to give midazolam 2 mg q 5 min until adequately sedated **3202**.

12 Alternatively, if lorazepam is greater than 10 mg IV q 4 hr, then the intensivist is  
13 prompted to give midazolam 5 mg q 5 min until adequately AND consider fentanyl and/or  
14 droperidol or Haldol for synergy despite delirium and pain assessment **3202**.

15 Yet another decision support routine is the sedation algorithm. Referring to **Figure**  
16 **37**, the sedation process decision support algorithm is illustrated. If an intensivist  
17 determines that a patient will require sedation, the intensivist may not be certain of all  
18 aspects that would be involved in this particular process. Therefore, the intensivist is lead  
19 through a decision support algorithm, which prompts the intensivist to conduct a sedation  
20 assessment based on: 1) scoring; 2) pain; and 3) delirium (see Assessment of Sedation  
21 algorithm) **3300**.

22 Following completion of the sedation assessment process **3300**, the intensivist is  
23 prompted to determine whether the patient is in pain **3302**. If this criteria is met, the  
24 intensivist is prompted to administer bolus morphine, fentanyl, other narcotic, start patient  
25 controlled analgesic (PCA) or epidural analgesia as indicated **3324**. If the patient is not in  
26 pain **3302** or after administering bolus morphine, fentanyl, other narcotic, start patient  
27 controlled analgesic (PCA) or epidural analgesia as indicated **3324**, the intensivist is  
28 prompted to determine whether the patient is delirious **3304**.

29 If the intensivist determines that the patient is delirious **3304**, he is prompted to  
30 administer droperidol 2.5-5 mg q30min prn and that he may consider IV Haldol not to  
31 exceed 30mg/24hr **3326**. If the patient is not delirious or after following the procedures in  
32 **3326**, the intensivist is prompted to determine whether the patient will need sedation for

1 more than the next 24 hours **3306**. If the patient will not need sedation for more than the  
2 next 24 hours **3306**, the process continues as described in **Figure 38**.

3 Alternatively, if the patient will need sedation for more than the next 24 hours  
4 **3306**, the intensivist is prompted to determine whether the sedation score is 8-10 **3308**. If  
5 this criteria is met, the intensivist is prompted to employ the Bolus sliding scale  
6 midazolam and increase lorazepam by 20 percent **3328** (see Bolus sliding scale midazolam  
7 algorithm – **Figure 36**). Subsequently, the intensivist is prompted to reassess sedation in 4  
8 hr **3330**.

9 If the sedation score is not 8-10, the intensivist is prompted to determine whether  
10 the sedation score is greater than or equal to the last Sed Scr after sedative bolus or  
11 increase **3310**. If this criteria is met, the intensivist is prompted to employ the procedures  
12 described above in **3328** and **3330**.

13 If the sedation score is not greater than or equal to the last Sed Scr after sedative  
14 bolus or increase **3310**, the intensivist is prompted to determine whether four (4) or more  
15 midaz boluses have been given since last q4hr assessment **3312**. If this criteria is met, the  
16 intensivist is prompted to employ the procedures described above in **3328** and **3330**.

17 Alternatively, if less than four (4) midaz boluses have been given since last q4hr  
18 assessment **3312**, the intensivist is prompted to determine whether the patient is  
19 adequately sedated **3314**. If this criteria is not met, the intensivist is prompted to employ  
20 the procedure described in **3328** and **3330**.

21 If the intensivist determines that the patient is adequately sedated **3314**, the  
22 intensivist is prompted to determine whether the sedation score is 0-2 **3316**. If this criteria  
23 is met, the intensivist is prompted to decrease lorazepam by 20 percent **3332** and reassess  
24 sedation in 4 hr **3334**.

25 Alternatively, if the sedation score is not 0-2 **3316**, the intensivist is prompted to  
26 determine whether the sedation score is less than or equal to the last Sed Scr after sedative  
27 decrease **3318**. If this criteria is met, the intensivist is prompted to employ the procedure  
28 described in **3332** and **3334**.

29 If the sedation score is not less than or equal to the last Sec Scr after sedative  
30 increase **3318**, the intensivist is prompted to determine whether the patient is clinically  
31 oversedated **3320**. If the patient is clinically oversedated **3320**, the intensivist is prompted  
32 to employ the procedure described in **3332** and **3334**. If the patient is not clinically



1       oversedated **3320**, the intensivist is prompted to reassess sedation in 4 hr **3322**.

2               Referring to **Figure 38**, the short term sedation process decision support algorithm  
3       of the present invention is illustrated. If an intensivist determines that a patient will not  
4       require sedation past the next 24 hour period, the intensivist may not be certain of all  
5       aspects that would be involved in this particular process. Therefore, the intensivist is lead  
6       through a decision support algorithm, which prompts the intensivist to conduct a sedation  
7       assessment based on: 1) scoring; 2) pain; and 3) delirium (see Assessment of Sedation  
8       algorithm) **3100**.

9               Following completion of the sedation assessment process **3100**, the intensivist is  
10       prompted to decrease lorazepam by 20 percent from baseline per day **3102**. The  
11       intensivist is prompted next to determine whether the patient is in pain **3104**. If this  
12       criteria is met, the intensivist is prompted to administer bolus morphine or fentanyl **3122**.  
13       If the patient is not in pain or after administering bolus morphine or fentanyl **3122**, the  
14       intensivist is prompted to determine whether the patient is delirious **3106**.

15               If the intensivist determines that the patient is delirious, he is prompted to  
16       administer droperidol 2.5-5 mg q30min prn **3124**. If the patient is not delirious or after  
17       administering droperidol **3124**, the intensivist is prompted to determine whether the  
18       sedation score is 8-10 **3108**.

19               If this criteria is met, the intensivist is prompted to employ the Bolus sliding scale  
20       midazolam (see Bolus sliding scale midazolam algorithm) and begin midazolam infusion  
21       or begin propofol 1-2 mg/kg bolus and 5-50 mcg/kg/min infusion **3126**. Subsequently, the  
22       intensivist is prompted to reassess sedation in 1 hr **3128**.

23               If the sedation score is not 8-10, the intensivist is prompted to determine whether  
24       the sedation score is greater than or equal to the last Sed Scr after sedative bolus or  
25       increase **3110**. If this criteria is met, the intensivist is prompted to employ the procedures  
26       described above in **3126** and **3128**.

27               If the intensivist determines that the sedation score is not greater than the last  
28       sedation score after sedative bolus or increase **3110**, the intensivist is prompted to  
29       determine whether the patient is adequately sedated **3112**. If this criteria is not met, the  
30       intensivist is prompted to employ the procedures described above in **3126** and **3128**.

31               If the intensivist determines that the patient is adequately sedated **3112**, he is  
32       prompted to determine whether the sedation score is 0-2 **3114**. If this criteria is met, the

1 intensivist is prompted to determine if the patient has been sedated for more than 72  
2 hours **3130**. If the patient has not been sedated for more than 72 hours **3130**, the  
3 intensivist is prompted to hold midazolam or propofol and hold or decrease lorazepam by  
4 50 percent **3132**. The intensivist is prompted subsequently to reassess sedation in 1 hour  
5 **3134**.

6 Alternatively, if the intensivist determines that the patient has been sedated for  
7 more than 72 hours **3130**, the intensivist is prompted to hold midazolam or propofol and  
8 decrease lorazepam by 20 percent per day **3136**. The intensivist is prompted  
9 subsequently to reassess sedation in 1 hour **3134**.

10 Alternatively, if the intensivist determines that the sedation score is not 0-2 **3114**,  
11 the intensivist is prompted to determine whether the sedation score is less than or equal to  
12 the last sedation screening after sedative decrease **3116**. If this criteria is met, the  
13 intensivist is prompted to determine whether the patient has been sedated for more than  
14 72 hours and to follow the procedures described above in **3130**.

15 If the intensivist determines that the sedation score is not less than or equal to the  
16 last Sed Scr after sedative decrease **3116**, the intensivist is prompted to determine  
17 whether the patient is clinically oversedated **3118**. If this criteria is met, the intensivist is  
18 prompted to determine whether the patient has been sedated for more than 72 hours and  
19 to follow the procedures described above in **3130**. If this criteria is not met, the  
20 intensivist is prompted to reassess sedation in 1 hr **3120**.

21 Referring to **Figure 39**, the respiratory isolation decision support algorithm is  
22 illustrated. If an intensivist determines that there may be a need for respiratory isolation,  
23 the intensivist may not be certain of all aspects that would be involved in this process.  
24 Therefore, the intensivist is lead through a decision support algorithm which prompts the  
25 intensivist to determine the need for respiratory isolation based upon: a) clinical  
26 assessment; and/or b) smear/culture findings **3500**.

27 Pursuing the clinical assessment branch of the decision support algorithm, the  
28 intensivist is prompted to determine whether the patient has known mTB (mycobacterium  
29 tuberculosis) **3502**. If this criteria is met, the intensivist is prompted to determine whether  
30 the patient has been compliant with their medications for over 2 weeks and is clinically  
31 responding **3512**. If the patient has not been compliant with their medications for over 2  
32 weeks and is not clinically responding **3512**, the intensivist is prompted that isolation is

1 required **3514**. If the patient has been compliant with their medications and is clinically  
2 responding **3512**, the intensivist is prompted that no isolation is required **3516**.

3 Alternatively, if the patient does not have known mTB **3502**, the intensivist is  
4 prompted to determine whether the patient has known mycobacterial disease other than  
5 TB **3504**. If this criteria is met, the intensivist is prompted to determine whether the  
6 patient has new CXR (chest x ray) findings and symptoms (cough 2 weeks, fever, weight  
7 loss) **3518**. If the patient does not have new CXR findings and symptoms **3518**, the  
8 intensivist is prompted that no isolation is required **3520**. If the patient does have new  
9 CXR findings and symptoms **3518**, the intensivist is prompted that isolation is required  
10 **3522**.

11 If the patient does not have known mycobacterial disease other than TB **3504**, the  
12 intensivist is prompted to determine whether there is a new cavitory lesion on CXR **3506**.  
13 If this criteria is met, the intensivist is prompted that isolation is required **3524**.

14 Alternatively, if there is no new cavitory lesion on CXR **3506**, the intensivist is  
15 prompted to determine whether there are pulmonary infiltrates or whether the patient is  
16 HIV (human immunodeficiency virus) positive **3508**. If this criteria is not met, the  
17 intensivist is prompted that no isolation is required **3510**. If this criteria is met, the  
18 intensivist is prompted to determine whether the patient has new CXR findings and  
19 symptoms (cough 2 weeks, fever, weight loss) **and** at high risk: 1) known mTB exposure;  
20 2) homeless; 3) prisoner; 4) travel to area with multi-drug resistant TB **3526**. If this  
21 criteria is met, the intensivist is prompted that isolation is required **3528**. Alternatively, if  
22 this criteria is not met, the intensivist is prompted that no isolation is required **3530**.

23 Pursuing the smear/culture branch of the decision support algorithm **3500**, the  
24 intensivist is prompted to determine whether the AFB (acid-fast bacilli) smear is positive  
25 **3532**. If the AFB smear is not positive, the intensivist is prompted that: no isolation is  
26 required; await culture results; if culture negative, no isolation required; if culture positive  
27 and patient has mycobacterial disease other than TB (MOTT no isolation is required; if the  
28 culture is positive and the patient does not have MOTT consult ID **3534**.

29 Alternatively, if the AFB smear is positive, the intensivist is prompted to determine  
30 whether the patient has known mycobacterial disease other than TB **3536**. If this criteria  
31 is not met, the intensivist is prompted that isolation is required **3538**. If this criteria is met,

the intensivist is prompted: to isolate until results of NAP test are in; if mTB positive isolate the patient; if no mTB, no isolation is required **3540**.

Referring to **Figure 40**, the empiric meningitis treatment decision support algorithm of the present invention is illustrated. If the intensivist is treating a patient for meningitis, the intensivist is prompted to answer a series of queries by the system to properly address medication and dosage. First, the intensivist is prompted to determine whether the patient has suffered a head trauma or undergone neurosurgery **3700**. The answer to this question is input 1 to **table x** below. The intensivist is next prompted to determine whether the patient is allergic to penicillin or is from an area where penicillin resistant staphylococcus pneumoniae is prevalent **3702**. The answer to this question becomes input 2 to **table x** below. The intensivist must also determine whether the patient is immunocompromised **3704**, and the answer becomes input 3 to **table x** below. The intensivist determines if the patient is over fifty years of age **3706**, with the answer being input 4 in **table x** below. Lastly, the intensivist is prompted to determine whether the patient has altered mental status **3708**, and the answer becomes input 5 in **table x** below. The inputs to each of these prompts **3702**, **3704**, **3706**, **3708** is compared to a dosage database according to the **Table 5** below.

**Table 5: Meningitis Input-Output Table**

Input	Combinations	Output
1	1 = yes 2 = no	A) vancomycin 1.5 – 2 gm IV q 12h + ceftazidime 2gm IV q 8 hr or cefapime 2gm IV q 8 hr
2	1 = yes 2 = no	B) vancomycin 1.5 – 2 gm IV q 12h + aztreonam 0.5 – 2 gm IV q 6-8 hr
3	1 = no 2 = no 3 = no 4 = yes	<u>ampicillin 2 gm IV q 4h</u>  + ceftriaxone 2 gm IV q12 cefotaxime 2 gm IV q 6 h
4	1 = no 2 = no 3 = no 4 = no	<u>ceftriaxone 2 gm IV q 12 hr</u>  or cefotaxime 2 gm IV q 6 hr
5	1 = no 2 = no 3 = yes	<u>ampicillin 2 gm IV q 4 hr</u>  +

		ceftazidime 2 gm IV q 8 hr or cefipime 2 gm IV q 8 hr
6	1 = no 2 = yes 3 = no 4 = yes	<u>vancomycin 1.5 – 2 gm IV q 12 hr</u>  + chloramphenicol 1 gm IV q 6 hr
7	1 = no 2 = yes 3 = no 4 = no	
8	1 = no 2 = yes 3 = yes	
9	5 = yes to inputs 3-8	add to output consider acyclovir 10 mg/kg IV q 8h

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In the Meningitis Input-Output Table, possible combinations of the five inputs are listed. For the conditions manifested in the patient, different drugs and dosages will be required. The proper treatment for each combination is listed in the output column of **Table x**. After the algorithm runs the comparison, the output is displayed on the computer screen, prompting the intensivist with the proper treatment **3712**.

Referring to **Figure 41**, the ventilator weaning decision support algorithm of the present invention is illustrated. The ventilator weaning decision support algorithm is used to determine whether an intensive care unit patient can return to breathing unassisted, and discontinue use of a ventilator. Such a determination requires evaluation of the patient by the intensivist over the course of several days.

To begin the decision process of whether to wean a patient from ventilator use, the intensivist is prompted to conduct daily screening, preferably during the hours of 06:00 a.m. to 10:00 a.m. **3800**. The daily screen prompts the intensivist to determine whether: the patients P/F ratio is greater than 200, the patient's positive end-expiratory pressure (PEEP) is less than or equal to 5, whether cough suctioning has been adequate and/or spontaneous, infusions with vasopressors have been necessary, and continuous infusions of sedatives or neuromuscular blocking agents have been necessary **3800**. If all conditions **3802** are answered no, the intensivist is directed by the system to repeat the daily screen **3805** the following morning. If all the conditions of the daily screen are met **3802**, the intensivist is prompted to perform additional tests.

If the patient has satisfied the daily screen, the intensivist is next directed to

1       conduct a rapid shallow breathing test **3804**. To perform the test, the intensivist is directed  
2       to change the ventilator setting to continuous positive airway pressure (CPAP) less than or  
3       equal to 5. In other words, there is no intermittent mandatory ventilation or pressure  
4       support provided for the patient. The patient is given one minute to reach a steady state of  
5       breathing. Then the intensivist measures the ratio of breaths per minute to tidal volume  
6       ( $f/V_T$ ). The intensivist next is prompted to determine whether the patient's  $f/V_T$  is less  
7       than or equal to 105 breaths per minute **3806**. If the patient's  $f/V_T$  is greater than 105  
8       breaths per minute, the intensivist is prompted to return to performing daily screening the  
9       following morning **3808**.

10       If the patient's  $f/V_T$  is less than or equal to 105 breaths per minute, the intensivist  
11       is next directed to perform a trial of spontaneous breathing. Here, the intensivist can either  
12       insert a T-Piece in the patient's airway or reduce the patient's CPAP to less than or equal  
13       to 5 over the course of two hours. The intensivist is prompted to observe the patient  
14       periodically in order to evaluate if the patient is breathing without assistance **3810**. The  
15       intensivist is prompted to perform a periodic assessment by determining whether: the  
16       patient's breathing characteristics are greater than 35 breaths per minute for 5 minutes, or  
17        $SpO_2$  is less than 90%, or the patient's Heart Rate (HR) is greater than 140, or HR deviates  
18       from the baseline breathing rate by more than 20%, or the patient's SBP is outside the  
19       range of 90 to 180. If any of the conditions are met, the intensivist is directed by the  
20       system to terminate ventilator weaning **3812**. If the conditions are not met, the patient is  
21       further assessed.

22       In further assessment, the intensivist is prompted to determine whether the patient  
23       has been able to breathe spontaneously for two hours, keep a clear airway, and does not  
24       have any procedures scheduled within twenty-four hours that would require the patient to  
25       be intubated **3814**. If the patient meets all of these criteria **3814**, the intensivist is notified  
26       by the system that the patient may be extubated **3816**. If the patient does not meet one or  
27       more of the criteria **3814**, the intensivist is prompted to perform steps for progressive  
28       weaning **3818**.

29       Referring to **Figure 41A**, the ventilator weaning decision support algorithm of the  
30       present invention is further illustrated. The intensivist, at his or her discretion may  
31       choose either T-piece progressive weaning or pressure support progressive weaning. In  
32       order to perform T-piece progressive weaning, the intensivist is directed to repeat the trial

1 of spontaneous breathing (as previously described **3810**). The intensivist can either insert  
2 a T-piece in the patient's airway or reduce the patient's CPAP to less than or equal to 5  
3 over the course of two hours. The intensivist is prompted to perform periodic assessment  
4 of the patient by either a two hour or 30 minute trial **3820**.

5 In order to perform pressure support progressive weaning, the intensivist is first  
6 prompted to observe whether the patient's pressure support (PS) rating is equal to eighteen  
7 plus or minus the positive end-expiratory pressure (PEEP). Next, the intensivist is  
8 directed by the system to regulate the pressure values in order to keep the patient's  
9 respiratory rate (RR) between twenty and thirty. Next, the intensivist is directed by the  
10 system to decrease the patient's pressure support by 2-4 centimeters of water two times  
11 per day. Once the patient maintains pressure support for at least two hours, the intensivist  
12 is prompted to further pursue extubating the patient **3822**.

13 After either T-Piece progressive weaning **3820** or pressure support progressive  
14 weaning **3822**, the intensivist is next prompted to perform a periodic assessment of the  
15 patient. Here, the intensivist must determine whether whether: the patient's breathing  
16 characteristics are greater than 35 breaths per minute for 5 minutes, or SpO<sub>2</sub> is less than  
17 90%, or the patient's HR is greater than 140, or HR deviates from the baseline breathing  
18 rate by more than 20%, or the patient's SBP is outside the range of 90 to 180. Where the  
19 patient meets any of these criteria, the intensivist is prompted to terminate weaning. If the  
20 patient meets none of these criteria, the intensivist is prompted to further assess the  
21 patient's ability to breath spontaneously **3824**.

22 In further assessment, the intensivist is prompted to determine whether the patient  
23 has been able to breathe spontaneously for two hours, keep a clear airway, and does not  
24 have any procedures scheduled within twenty-four hours that would require the patient to  
25 be intubated **3826**. If the patient meets all of these criteria **3814**, the intensivist is notified  
26 by the system that the patient may be extubated **3828**. If the patient does not meet one or  
27 more of the criteria **3826**, the intensivist is directed by the system to allow the patient to  
28 rest for at least twelve hours at A/C, the last level of pressure support the patient achieved  
29 **3830**. The intensivist is prompted to resume progressive weaning the following day **3832**.

30 Referring to **Figure 42**, the Warfarin Dosing Algorithm of the present invention is  
31 illustrated. The intensivist is first prompted to give the initial dose and determine  
32 subsequent dosage each day **3900**. When the intensivist determines subsequent dosage, he

is first prompted to determine the patient's target INR **3902**. If the patient's target INR ranges from 2.0 to 3.0, the intensivist is prompted by the system to make further determinations relevant to dosage. The intensivist is directed by the system to determine whether the patient is taking drugs that effect prothrombin time **3904**, the baseline INR value **3906**, and whether rapid anticoagulation is required **3908**. Each answer is assigned a point value, and the total points are tabulated. If the point value is greater than one, the system refers to the 10 milligram load target database for dosing. If the point value is less than one, the system refers to the 5 milligram load target database for dosing **3910**.

At the initial INR determination **3902**, if the patient's INR was initially between 1.5 and 2.0, the system refers to the 5 milligram load target database for dosing. If the patient's INR was initially between 3.0 and 4.0, the system refers to the 10 milligram load target database for dosing **3910**. Next the intensivist is prompted to enter the day of treatment **3912** and the patient's INR **3914**. Depending on whether the system has been directed to the 5 milligram load target or the 10 milligram load target, a comparison is run **3916** according to the following tables.

**5 mg Load Target INR 1.5-2.0**

Day	<1.5	1.5-2	2-2.5	>2.5
2	5	1.25 - 2.5	0	0
3	5-7.5	1.25 - 2.5	0 - 1.25	0
4	10- (Check to see whether pt has received vit K)	1.25 - 2.5	0 - 1.25	0
5	10 (Check to see whether pt Has received vit K)	2.5 - 5	0 - 2.5	0 - 1.25
6	15 Obtain hematology consultation.	2.5 - 5	1.25 - 2.5	0 - 1.25



**10 mg Load Target INR 3.0-4.0**

Day	<1.5	1.5-2	2-2.5	2.5-3	>3
2	10	7.5 - 10	5-7.5	2.5-5.0	0-2.5
3	10 -15	7.5 - 10	5-7.5	2.5 - 5	2.5-5
4	10 -15 (Check to see whether pt has received vit K)	7.5 -12.5	5 - 10	5-7.5	2.5-5
5	15 (Check to see whether pt has received vit K)	10 - 12.5	7.5-10	5 - 7.5	2.5-5
6	15-20 obtain hematology consultation.	10 - 15	7.5-12.5	5 - 10	5-7.5

The appropriate dosage and instructions is displayed on the computer screen to the intensivist **3918**.

Referring to **Figure 43**, the heparin-induced thrombocytopenia (HIT) decision support algorithm of the present invention is illustrated. The intensivist is prompted to observe whether the patient's platelet count has dropped 50% or more over seventy-two hours while being treated with heparin, and whether any other obvious causes of platelet reduction might be present **4100**. If such a drop has not occurred, the intensivist is notified by the system that the patient most likely does not have HIT, but monitoring of the platelet count should continue **4102**. If the patient's platelet count has drastically dropped, the intensivist is prompted to determine whether the patient has been treated with heparin for more than three days **4104**. Regardless of the answer, the intensivist is next prompted to determine if the patient has been treated with heparin in the preceeding three months **4106**. If the patient has not received heparin in the preceeding three months, the intensivist is notified by the system that HIT is not likely to be the cause of the platelet drop. The intensivist is also prompted to monitor platelet count for infection or other thrombocytopenia-causing drugs, and to consider stopping heparin therapy if the platelet count drops below 50,000 per cubic millimeter **4108**.

If the patient has received heparin in the last three days **4104**, the intensivist is further prompted to look for signs of thrombosis, or blood clotting **4110**. If the patient

1 shows signs of thrombosis, the intensivist is notified by the system that the patient is likely  
2 to have HIT. Accordingly, the intensivist is prompted to stop administering heparin and  
3 flush any drug administration equipment that would contain heparin traces. The  
4 intensivist is also provided instructions by the system to treat a patient still requiring  
5 anticoagulation treatment with alternate drugs and methods **4112**.

6 Where the patient does not show signs of thrombosis **4110**, the intensivist is  
7 prompted to check for heparin resistance **4114**. Signs of heparin resistance include  
8 inability to hold aPTT though heparin doses have been increase. If the patient shows signs  
9 of heparin resistance, the intensivist is prompted to consider stopping heparin treatment  
10 and to consider treating a patient still requiring anticoagulation treatment with alternate  
11 drugs and methods **4116**. If the patient does not show signs of heparin resistance, the  
12 intensivist is notified by the system that the patient possibly has HIT. The intensivist is  
13 accordingly prompted to continue monitoring for thrombosis, consider infection or other  
14 drugs that cause thrombocytopenia, and to consider stopping heparin therapy if the platelet  
15 count drops below 50,000 per cubic millimeter **4118**.

#### 16 **Video Visitation**

17 Referring to **Figure 44**, a video visitation system according to an alternate  
18 embodiment of the present invention is illustrated. The video visitation system allows  
19 Remote Visitation Participants (RVPs) at remote terminals **4202**, **4204**, **4206** to participate  
20 in a video/audio conferencing session with a Local Visitation Participant(s) (LVPs) at a  
21 patient site **4240** under supervision of a conferencing workstation **4230**. RVPs include,  
22 but are not limited to, family members or other concerned parties. LVPs include, but are  
23 not limited to, patients, nurses, doctors, family members or other concerned parties.

24 RVPs can see and converse with LVPs. RVPs can control the camera in a patient's  
25 room/residence (e.g. zoom, left, right, and up.) LVPs can converse with RVPs in a  
26 patient's room/residence. LVPs can see and converse with RVPs at the video/audio  
27 conferencing workstation located locally to the patient's room/residence (e.g. the hospital  
28 ward the patient resides in).

29 RVPs will attempt to initiate or join a video/audio conference from a remote  
30 terminal **4202**, **4204**, **4206** via an internet/intranet network **4210**. Upon an attempt to enter  
31 the video/audio conference **4220**, the RVP will be authenticated to confirm identity and  
32 subsequent remote visitation privileges.

1           The rationale underlying the video visitation system is primarily the ability to  
2 allow family members the capability to "virtually visit" other sick family members when a  
3 physical visit to a patient's location is not possible and/or desirable. The "virtual visit"  
4 further allows the possibility to see and speak with health care professionals regarding a  
5 patient's care or related subjects without having to be physically located at the health care  
6 professional's location.

## 7       **Results**

8           The structure of the present invention and its efficacy have yielded striking results  
9 in practice. In a research setting, deployment of certain rudimentary aspects of the present  
10 the invention designed to experimentally test the approach described and developed in  
11 detail above, yielded unprecedented improvements in clinical and economic outcomes:  
12 50% improvement in severity adjusted mortality, 40% improvement in clinical  
13 complication rates, 30% improvement in ICU length of stay, and 30% improvement in  
14 overall ICU cost of care.

15          A system and method of remote monitoring of ICU's and other healthcare locations  
16 has been shown. It will be apparent to those skilled in the art that other variations of the  
17 present invention are possible without departing from the scope of the invention as  
18 disclosed. For example, one can envision different ratios of command center/remote  
19 location to ICU's, other decision support algorithms that would be used by intensivists,  
20 other types of remote monitoring of not only ICU's but other types of hospital functions as  
21 well as industrial functions where critical expertise is in limited supply but where that  
22 expertise must be applied to ongoing processes. In such cases a system such as that  
23 described can be employed to monitor processes and to provide standardized interventions  
24 across a number of geographically dispersed locations and operations.

**We claim:**

- 1 1. A system for providing continuous, expert network health care services from a remote  
2 location comprising:  
3 a plurality of health care locations;  
4 at least one remote command center for managing healthcare at said plurality of health  
5 care locations; and at least one network;  
6 wherein said plurality of health care locations are electronically connected to said at least  
7 one remote command center by the network, and wherein said at least one remote  
8 command center provides intensivist monitoring of the plurality of health care locations 24  
9 hours per day, seven days per week.
- 1 2. The system for providing continuous, expert network health care services from a  
2 remote location of claim 1 wherein said remote command center further comprises a  
3 computerized patient care management system for monitoring and treating individual  
4 patients at any of said plurality of healthcare locations.
- 1 3. The system for providing continuous, expert network health care services from a  
2 remote location of claim 2 wherein said computerized patient care management system  
3 further comprises a data server/data warehouse for storing and analyzing data from the at  
4 least one remote command center.
- 1 4. The system for providing continuous, expert network health care services from a  
2 remote location of claim 1 wherein each of the plurality of health care locations further  
3 comprises patient monitoring equipment electronically connected to the at least one  
4 remote command center over the network.
- 1 5. The system for providing continuous, expert network health care services from a  
2 remote location of claim 4 wherein each health care location further comprises a nurses'  
3 station electronically connected to said monitoring equipment and to the at least one  
4 remote command center over the network.
- 1 6. The system for providing continuous, expert network health care services from a  
2 remote location of claim 1 wherein the healthcare locations comprise intensive care units  
3 (ICU's).

1 7. The system for providing continuous, expert network health care services from a  
2 remote location of claim 2 wherein said computerized patient care management system  
3 further comprises a relational database for storing a plurality of decision support  
4 algorithms and for prompting intensivists to provide care to patients based upon the any of  
5 the decision support algorithms.

1 8. The system for providing continuous, expert network health care services from a  
2 remote location of claim 7 wherein said algorithms are selected from the group consisting  
3 of algorithms for treating:

4 Acalculous Cholecystitis, Acute Pancreatitis Algorithm, Acute Renal Failure-Diagnosis,  
5 Acute Renal Failure-Management & Treatment, Adrenal Insufficiency, Agitation and  
6 Anxiety, Depression & Withdrawal, Aminoglycoside Dosing and Therapeutic Monitoring,  
7 an Amphotericin-B Treatment Guidelines, Analgesia, Antibiotic Classification & Costs,  
8 Antibigrams Algorithm, Antibiotic associated Colitis Algorithm, ARDS: Hemodynamic  
9 Management, ARDS: Steroid Use, ARDS: Ventilator Strategies, Asthma, Bleeding  
10 Patient, Bloodstream Infections, Blunt Cardiac Injury, Bradyarrhythmias, Brain Death,  
11 Bronchodilator Use in Ventilator Patients, Bronchoscopy & Thoracentesis Guidelines,  
12 Candiduria, Cardiogenic Shock, CardioPulmonary Resuscitation Guideline, Catheter  
13 Related Septicemia, a Catheter Replacement Strategies, Cervical Cord Injury, Congestive  
14 Heart Failure , Copd Exacerbation & Treatment, CXR (Indications), Dealing with  
15 Difficult patients and families, Diabetic Ketoacidosis, Dialysis, Diurectic Use, Drug  
16 Changes with Renal Dysfunction, Emergency Cardiac Pacing, Endocarditis Diagnosis and  
17 Treatment, Endocarditis Prophylaxis, End of Life Decisions, Endotracheal Tubes &  
18 Tracheotomy, Ethical Guidelines, Febrile Neutropenia, FUO, Fluid Resusditation,  
19 Guillain-Barre Syndrome, Heparin, Heparin-Induced Thrombocytopenia, Hepatic  
20 Encephalopathy, Hepatic Failure, HIV + Patent Infections, Hypercalcemia Diagnosis  
21 and Treatment, Hypercalcemia Insulin Treatment, Hyperkalemia : Etiology & Treatment,  
22 Hyponatremia : Etiology & Treatment, Hypertensive Crisis, Hypokalemia : Etiology &  
23 Treatment, Hyponatremia : Etiology & Treatment, Hypothermia, Identification of  
24 Cervical Cord Injury, Implantable Cardio-defibrillator, Intra-Aortic Balloon Device,  
25 Intracerebral Hemorrhage, Latex Allergy, Magnesium Administration, Management of  
26 Hypotension, Inotropes , Management of Patients with Ascites, Empiric Meningitis,

27 Meningitis, a Myasthenia Gravis, Myocardial Infarction, Myocardial Infarction with left  
 28 bundle branch block, Necrotizing Soft Tissue Infections, Neuromuscular Blockers,  
 29 Neuromuscular Complications of Critical Illness, Non-Infectious Causes of Fever, Non-  
 30 Traumatic Coma, Noninvasive Modes of Ventilation, Nutritional Management,  
 31 Obstetrical Complication, Oliguria, Oliguria, Open Fractures, Open Fractures,  
 32 Ophthalmic Infections, Organ Procurement Guidelines, PA Catheter Guideline and  
 33 Troubleshooting, Pancreatitis, Penetrating Abdominal Injury, Penetrating Chest Injury,  
 34 Penicillin Allergy, Penicillin Allergy, Permanent Pacemaker and Indications, Pneumonia  
 35 Community Acquired, Pneumonia Hospital Acquired, Post-Op Bleeding, Post-Op  
 36 Hypertension, Post-Op Hypertension, Post-Op Management of Abdominal, Post-Op  
 37 Management of Carotid, Post-Op Management of Open Heart, Post-Op Management of  
 38 Thoracotomy, Post-Op Myocardial Ischemia (Non-Cardiac Arrhythmias after Cardiac  
 39 Surgery), Post-Op Power Weaning, Pressure Ulcers, Pulmonary Embolism Diagnosis,  
 40 Pulmonary Embolism Treatment, Respiratory Isolation, Sedation, Seizure, Status  
 41 Epilepticus, Stroke, Sub-Arachnoid Hemorrhage, Supra-Ventricular Tachyarrhythmia,  
 42 Supra-Ventricular Tachycardia, Wide Complex QRS Tachycardia, Therapeutic Drug  
 43 Monitoring, Thrombocytopenia, Thrombolytic Therapy, Transfusion Guidelines,  
 44 Traumatic Brain Injury, Assessment of Sedation, Sedation, Septic Shock, Bolus Sliding  
 45 Scale Midazolam, Short Term Sedation Process, Sinusitis, SIRS, Spinal Cord Injury,  
 46 Steroid Replacement Strategy, Thyroid Disease, Transplant Infection Prophylaxis,  
 47 Transplant Related Infections, Treatment of Airway Obstruction, Unknown Poisoning,  
 48 Unstable Angina, Upper GI Bleeding Stress Prophylaxis, Vancomycin, Upper GI  
 49 Bleeding Non-Variceal, Upper GI Bleeding Variceal, Use of Hematopoietic Growth  
 50 Factors, Ventilator Weaning, Ventilator Weaning Protocol, Venous Thrombosis  
 51 Diagnostic and Treatment, Venous Thromboembolism Prophylaxis, Ventricular  
 52 Arrhythmia, Warfarin, Warfarin Dosing, and Wound Healing Strategies.

1 9. The system for providing continuous, expert network health care services from a  
 2 remote location of claim 2 wherein said computerized patient care management system  
 3 further comprises order writing software for providing knowledge-based recommendations  
 4 and prescriptions for medication based upon the clinical data.

1 10. The system for providing continuous, expert network health care services from a

2 remote location of claim 2 wherein said computerized patient care management system  
3 further comprises knowledge-based vital sign/hemodynamic algorithms that prompt said  
4 intensivist to engage in early intervention.

1 11. The system for providing continuous, expert network health care services from a  
2 remote location of claim 1, further comprising:  
3 audio-video conference apparatus located at the plurality of health care locations; and  
4 remote visitation terminals for connection to audio-video conference apparatus at any of  
5 the plurality of health care locations via the network;  
6 wherein remote a visitation participant at one of the remote visitation terminals  
7 communicates with a local visitation participants at the plurality of health care locations.

1 12. A method for providing continuous expert critical care comprising:  
2 monitoring patients in a plurality of ICU's;  
3 communicating the information from the patient monitoring to at least one command  
4 center over a first network  
5 receiving and analyzing the information from the patient monitoring at the command  
6 center over the first network; and  
7 providing guidance from the command center to the plurality of ICU's to take actions  
8 regarding patient care.

1 13. The method for providing continuous expert critical care of claim 12 wherein the  
2 providing guidance from the command center further comprises an intensivist reviewing  
3 decision support algorithms that provide guidance for treating a plurality of critical care  
4 conditions.

1 14. The method for providing continuous expert critical care of claim 13 wherein the  
2 decision support algorithms are taken from the group consisting of algorithms for treating:  
3 Acalculous Cholecystitis, Acute Pancreatitis Algorithm, Acute Renal Failure-Diagnosis,  
4 Acute Renal Failure-Management & Treatment, Adrenal Insufficiency, Agitation and  
5 Anxiety, Depression & Withdrawal, Aminoglycoside Dosing and Therapeutic Monitoring,  
6 an Amphotericin-B Treatment Guidelines, Analgesia, Antibiotic Classification & Costs,  
7 Antibiograms Algorithm, Antibiotic associated Colitis Algorithm, ARDS: Hemodynamic

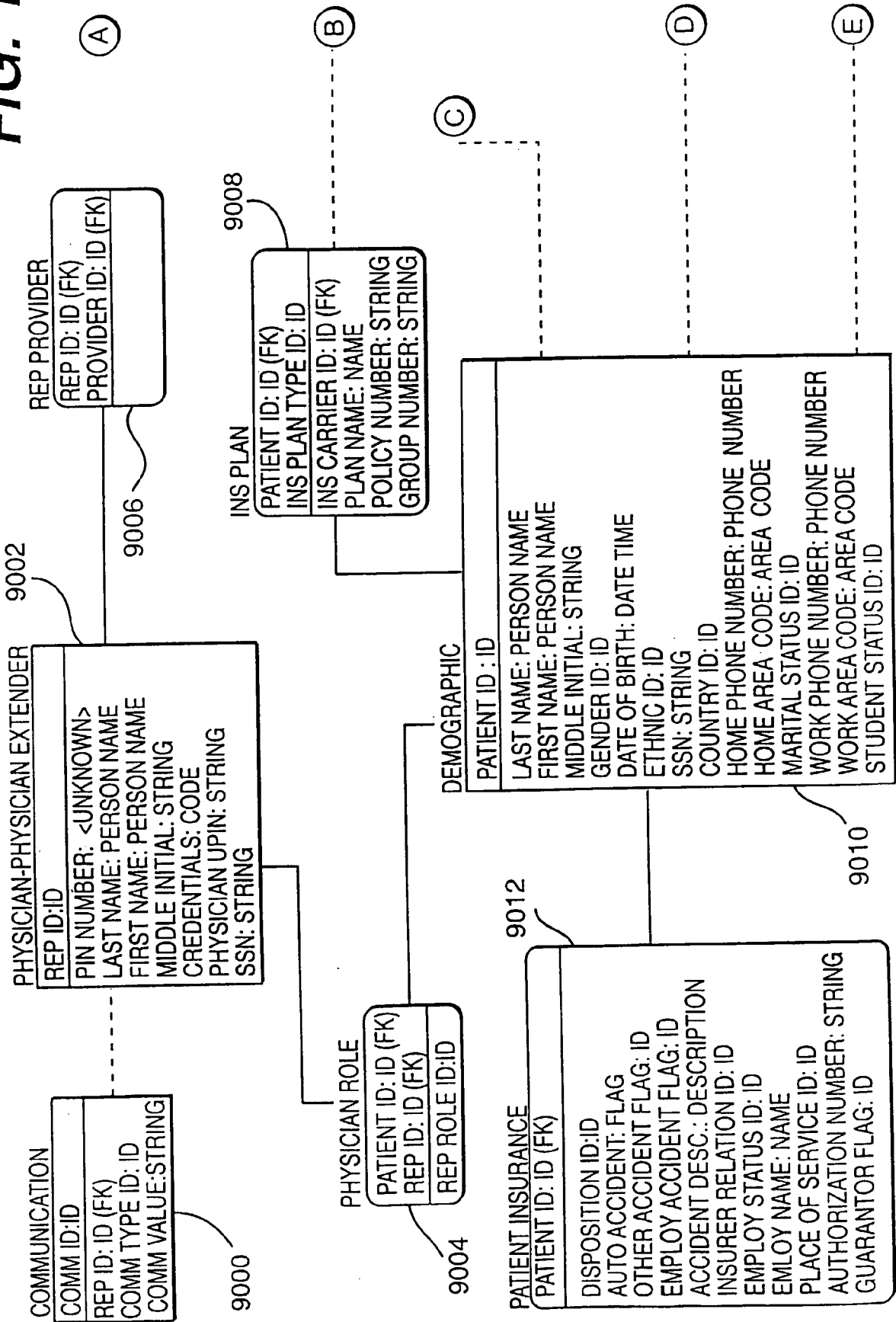
8 Management, ARDS: Steroid Use, ARDS: Ventilator Strategies, Asthma, Bleeding  
 9 Patient, Bloodstream Infections, Blunt Cardiac Injury, Bradyarrhythmias, Brain Death,  
 10 Bronchodilator Use in Ventilator Patients, Bronchoscopy & Thoracentesis Guidelines,  
 11 Candiduria, Cardiogenic Shock, CardioPulmonary Resuscitation Guideline, Catheter  
 12 Related Septicemia, a Catheter Replacement Strategies, Cervical Cord Injury, Congestive  
 13 Heart Failure , Copd Exacerbation & Treatment, CXR (Indications), Dealing with  
 14 Difficult patients and families, Diabetic Ketoacidosis, Dialysis, Diurectic Use, Drug  
 15 Changes with Renal Dysfunction, Emergency Cardiac Pacing, Endocarditis Diagnosis and  
 16 Treatment, Endocarditis Prophylaxis, End of Life Decisions, Endotracheal Tubes &  
 17 Tracheotomy, Ethical Guidelines, Febrile Neutropenia, FUO, Fluid Resusditation,  
 18 Guillain-Barre Syndrome, Heparin, Heparin-Induced Thrombocytopenia, Hepatic  
 19 Encephalopathy, Hepatic Failure, HIV + Patent Infections, Hypercalcemia Diagnosis  
 20 and Treatment, Hypercalcemia Insulin Treatment, Hyperkalemia : Etiology & Treatment,  
 21 Hyponatremia : Etiology & Treatment, Hypertensive Crisis, Hypokalemia : Etiology &  
 22 Treatment, Hyponatremia : Etiology & Treatment, Hypothermia, Identification of  
 23 Cervical Cord Injury, Implantable Cardio-defibrillator, Intra-Aortic Balloon Device,  
 24 Intracerebral Hemorrhage, Latex Allergy, Magnesium Administration, Management of  
 25 Hypotension, Inotropes , Management of Patients with Ascites, Empiric Meningitis,  
 26 Meningitis,a Myasthenia Gravis, Myocardial Infarction, Myocardial Infarction with left  
 27 bundle branch block, Necrotizing Soft Tissue Infections, Neuromuscular Blockers,  
 28 Neuromuscular Complications of Critical Illness, Non-Infectious Causes of Fever, Non-  
 29 Traumatic Coma, Noninvasive Modes of Ventilation, Nutritional Management,  
 30 Obstetrical Complication, Oliguria, Oliguria, Open Fractures, Open Fractures,  
 31 Ophthalmic Infections, Organ Procurement Guidelines, PA Catheter Guideline and  
 32 Troubleshooting, Pancreatitis, Penetrating Abdominal Injury, Penetrating Chest Injury,  
 33 Penicillin Allergy, Penicillin Allergy, Permanent Pacemaker and Indications, Pneumonia  
 34 Community Acquired, Pneumonia Hospital Acquired, Post-Op Bleeding, Post-Op  
 35 Hypertension, Post-Op Hypertension , Post-Op Management of Abdominal, Post-Op  
 36 Management of Carotid, Post-Op Management of Open Heart, Post-Op Management of  
 37 Thoracotomy, Post-Op Myocardial Ischemia (Non-Cardiac Arrhythmias after Cardiac  
 38 Surgery), Post-Op Power Weaning, Pressure Ulcers, Pulmonary Embolism Diagnosis,  
 39 Pulmonary Embolism Treatment, Respiratory Isolation, Sedation, Seizure, Status

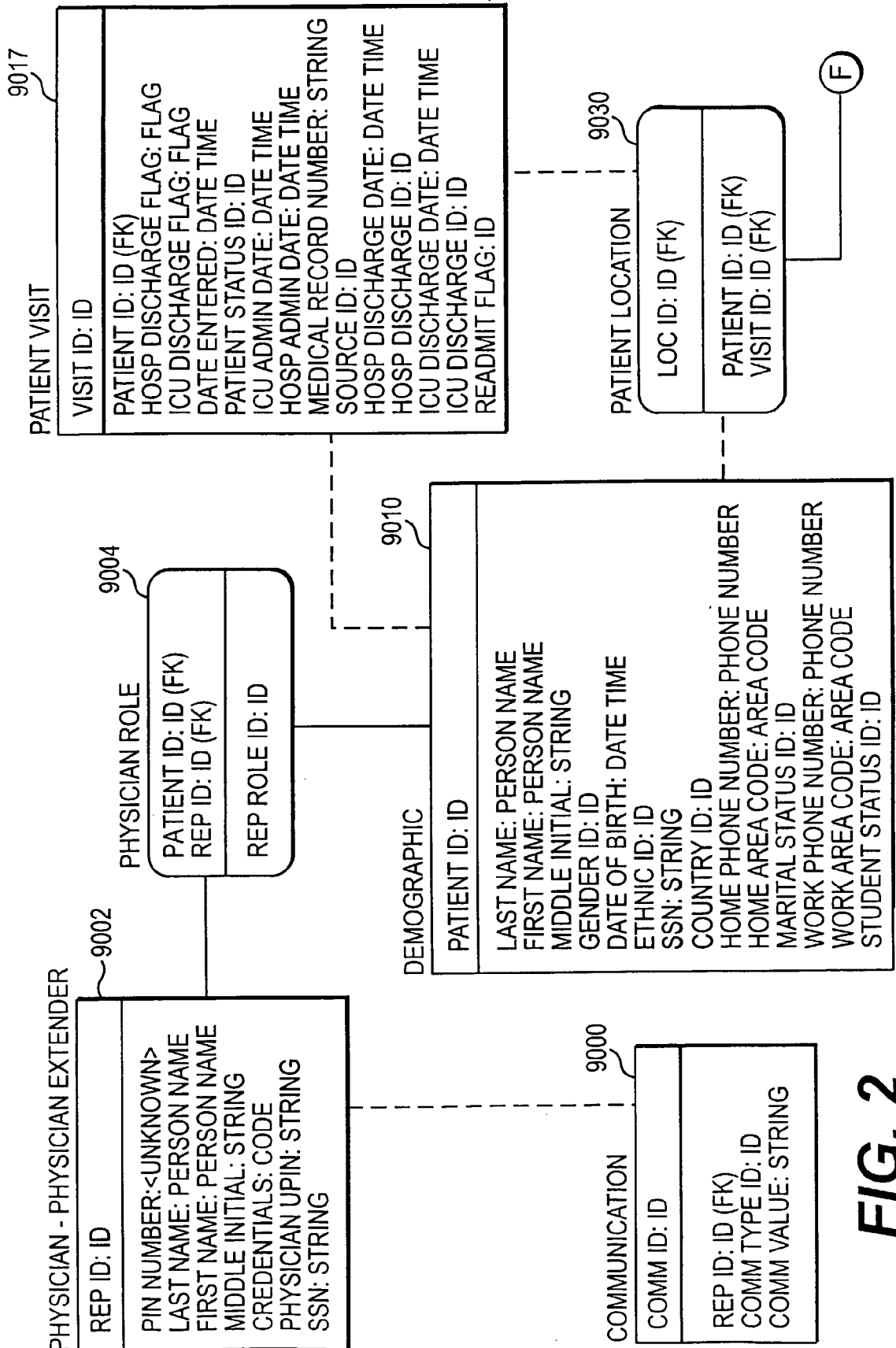


40      Epilepticus, Stroke, Sub-Arachnoid Hemorrhage, Supra-Ventricular Tachyarrythmia,  
41      Supra-Ventricular Tachycardia, Wide Complex QRS Tachycardia, Therapeutic Drug  
42      Montoring, Thrombocytopenia, Thrombolytic Therapy, Transfusion Guidelines,  
43      Traumatic Brain Injury, Assessment of Sedation, Sedation, Septic Shock, Bolus Sliding  
44      Scale Midazolam, Short Term Sedation Process, Sinusitis, SIRS, Spinal Cord Injury,  
45      Steroid Replacement Strategy, Thyroid Disease, Transplant Infection Prophylaxis,  
46      Transplant Related Infections, Treatment of Airway Obstruction,Unknown Poisoning,  
47      Unstable Angina, Upper GI Bleeding Stress Prophylaxis, Vancomycin, Upper GI  
48      Bleeding Non-Variceal, Upper GI Bleeding Variceal , Use of Hematopoetic Growth  
49      Factors, Ventilator Weaning, Ventilator Weaning Protocol, Venous Thrombosis  
50      Diagnostic and Treatment, Venous Thromboembolism Phrophylaxis, Ventricular  
51      Arrythmia, Warfarin, Warfarin Dosing, and Wound Healing Strategies.

1      15. The method for providing continuous expert critical care of claim 13 further  
2      comprising a data server/ data warehouse storing and analyzing patient data from the at  
3      least one command center and providing analysis in results over a second network to the at  
4      least one command center.

FIG. 1





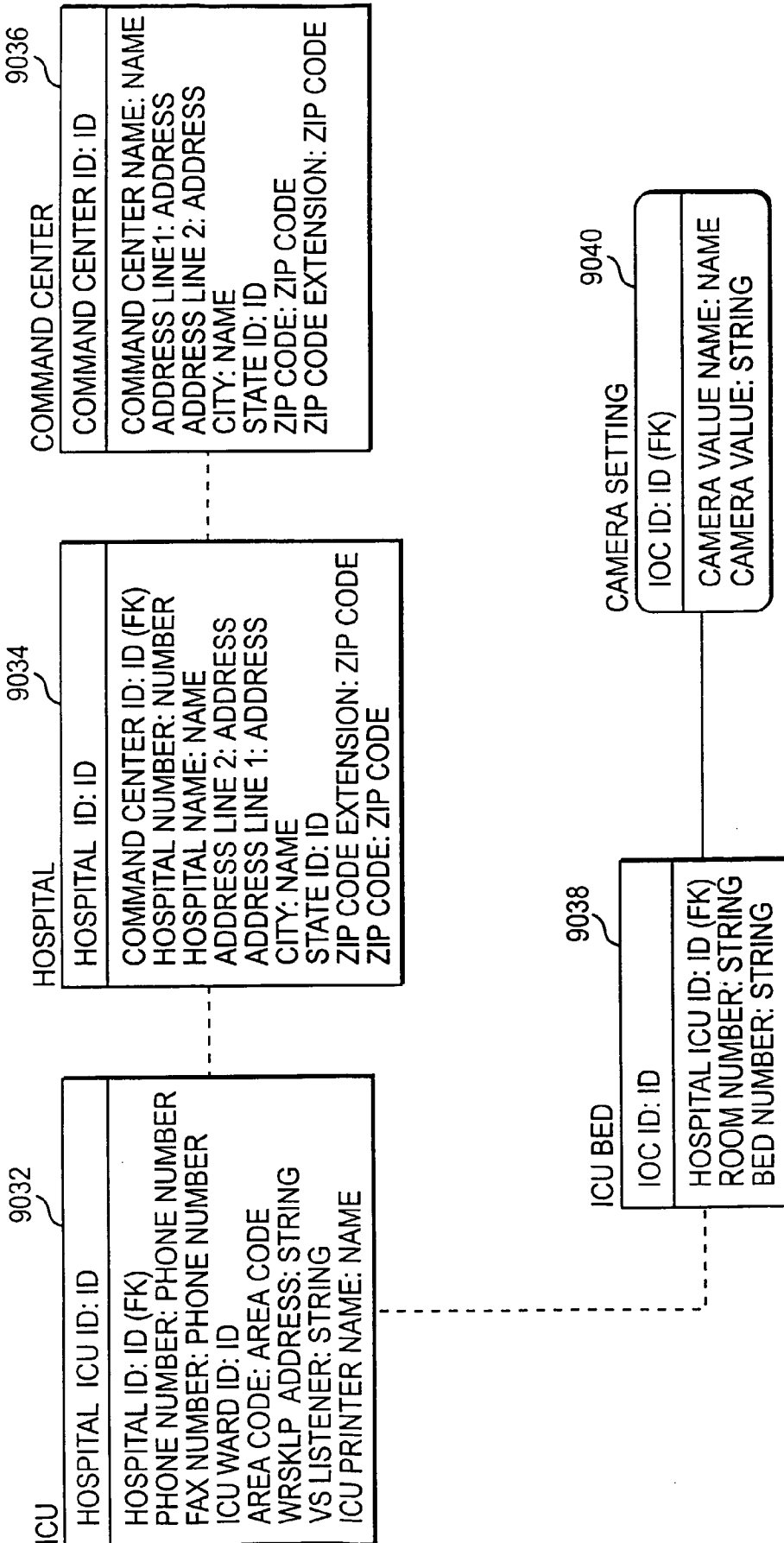


FIG. 2A

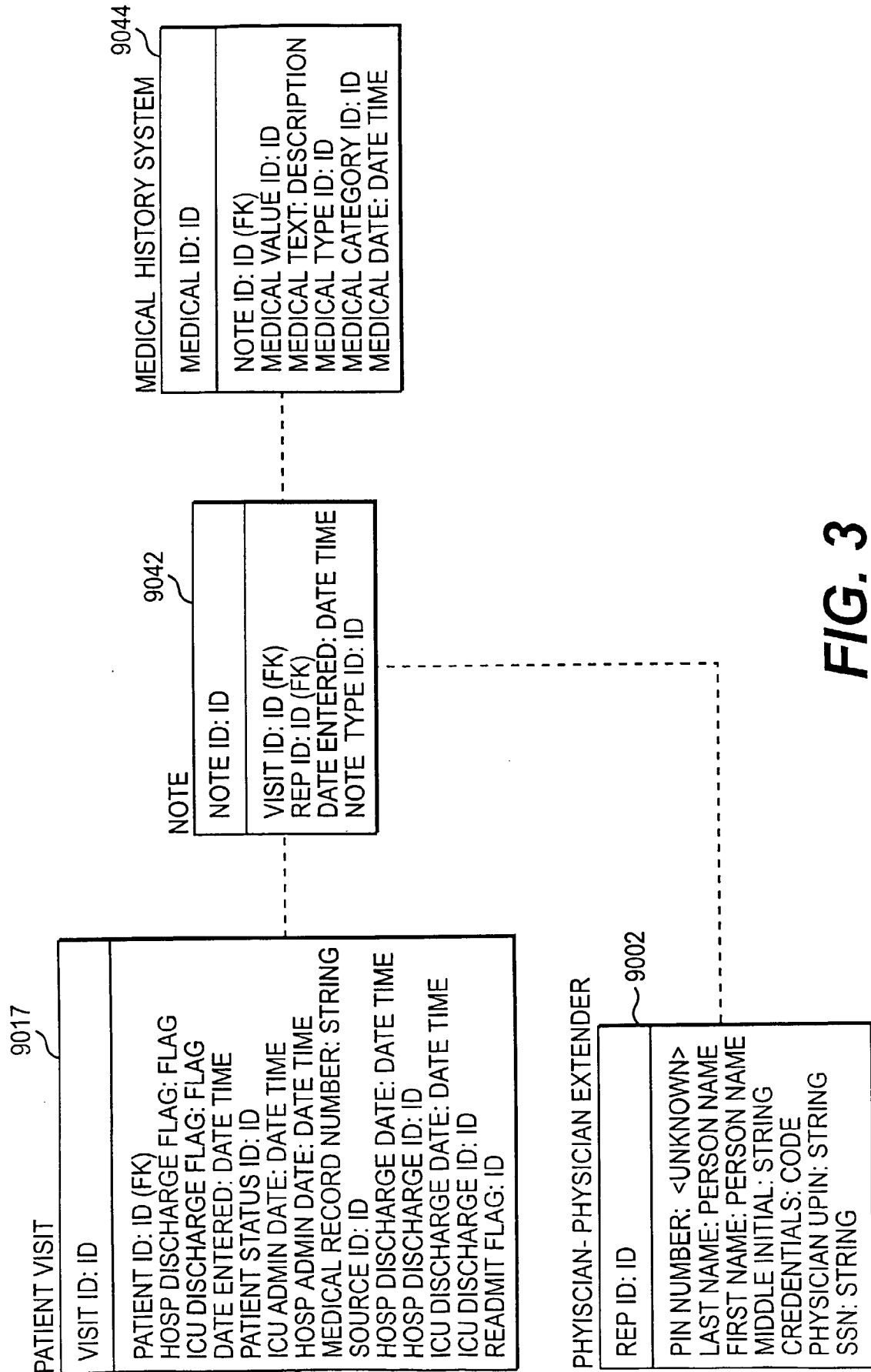
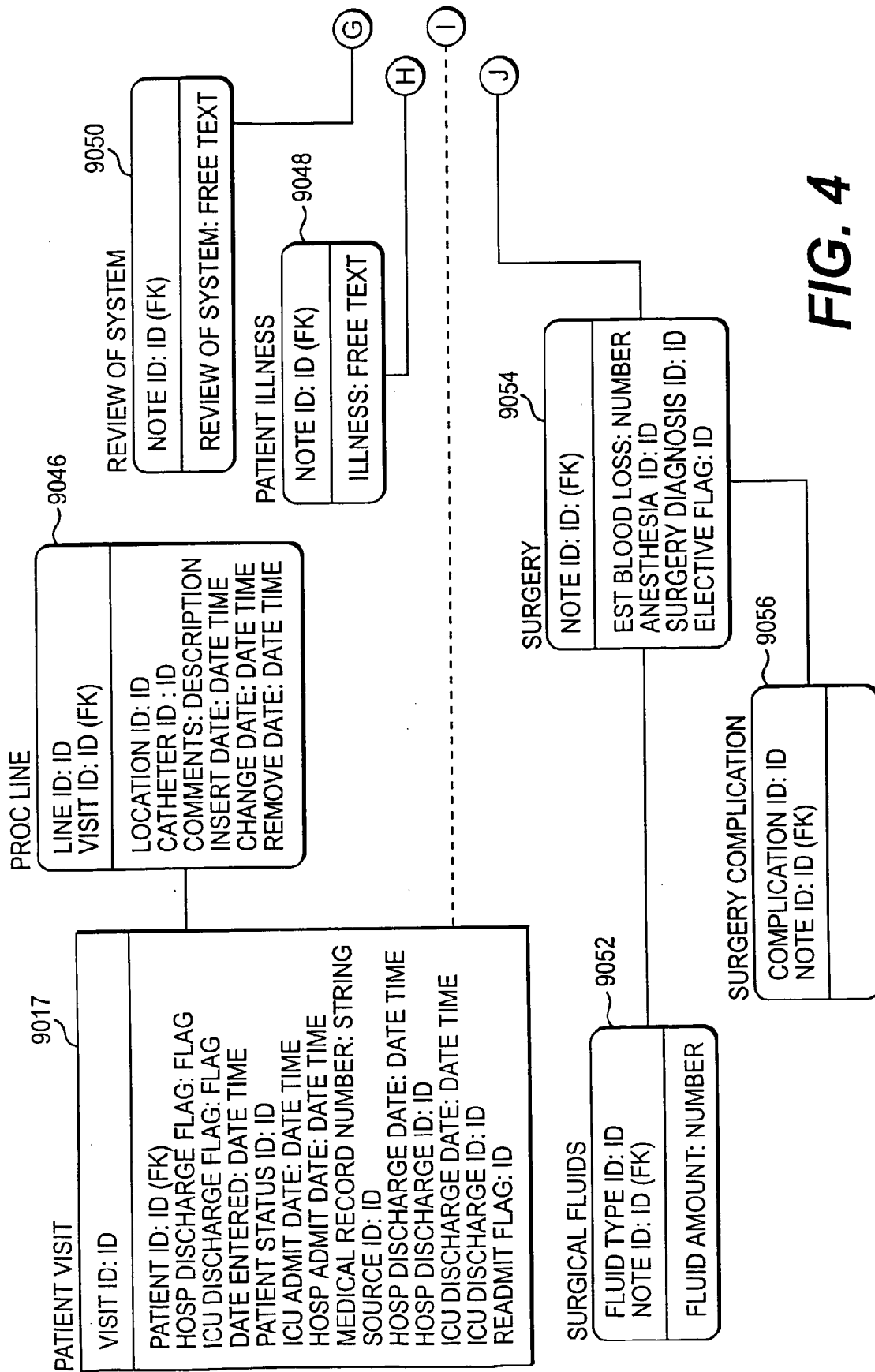


FIG. 3



**FIG. 4**

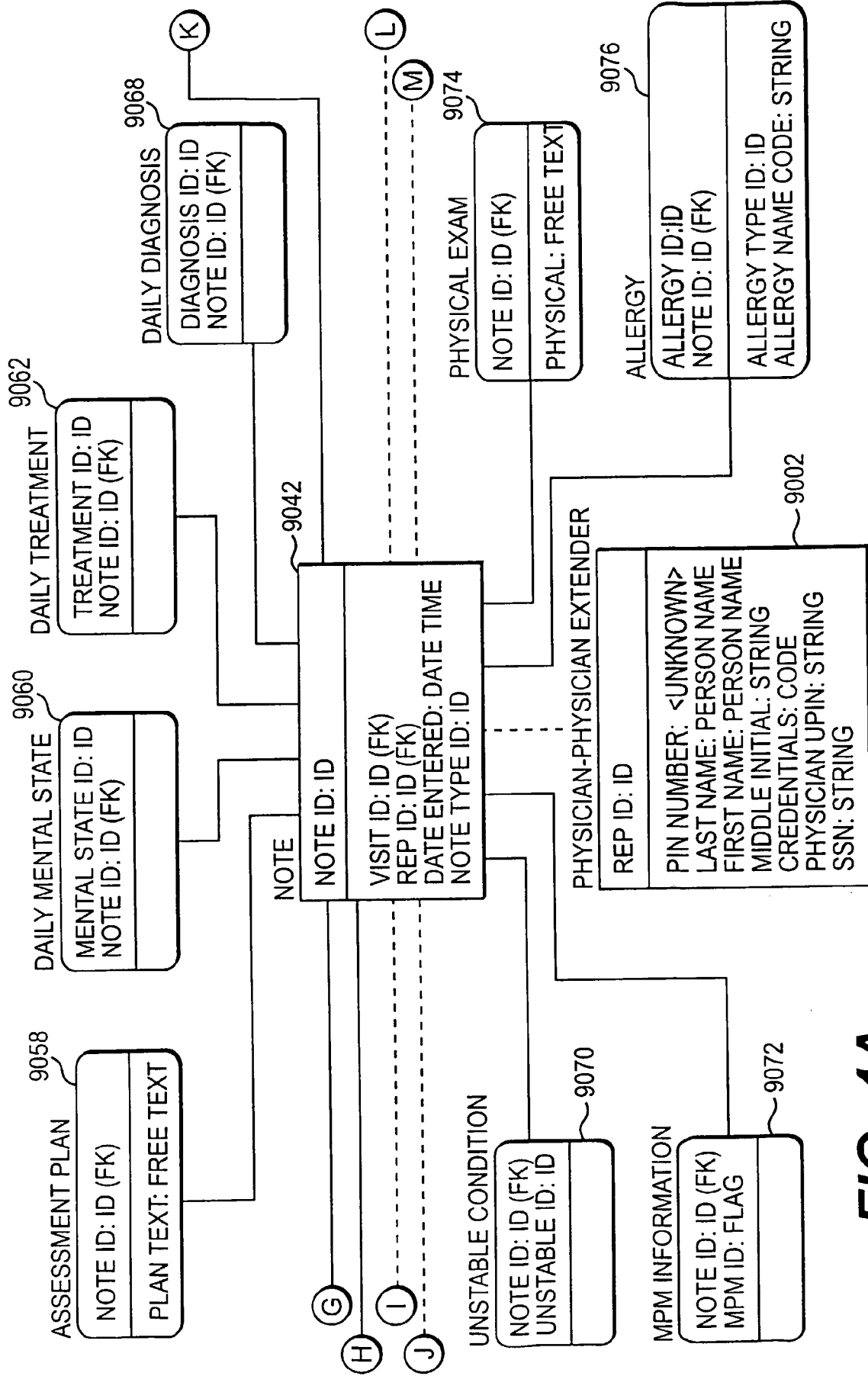


FIG. 4A

FIG. 4B

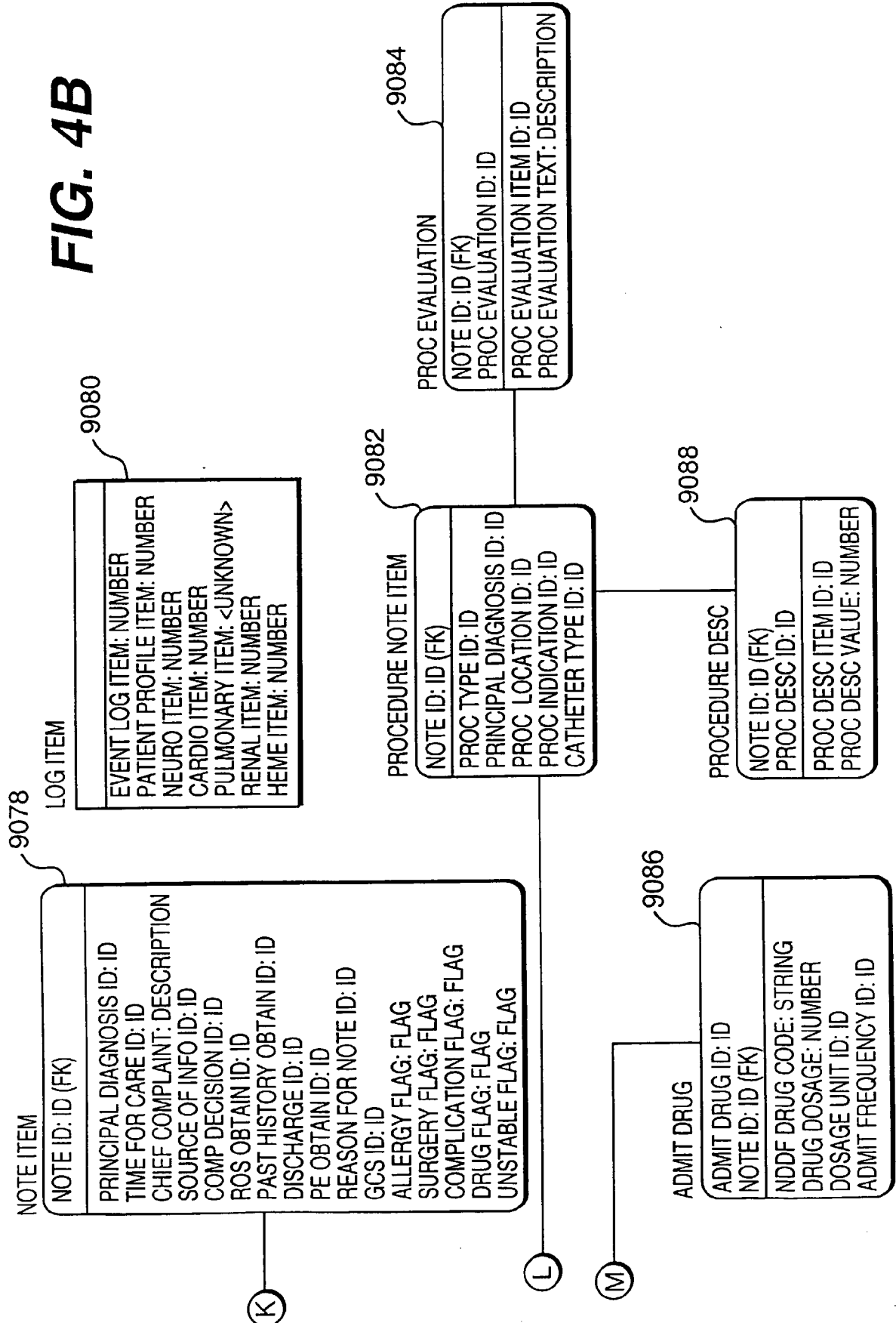
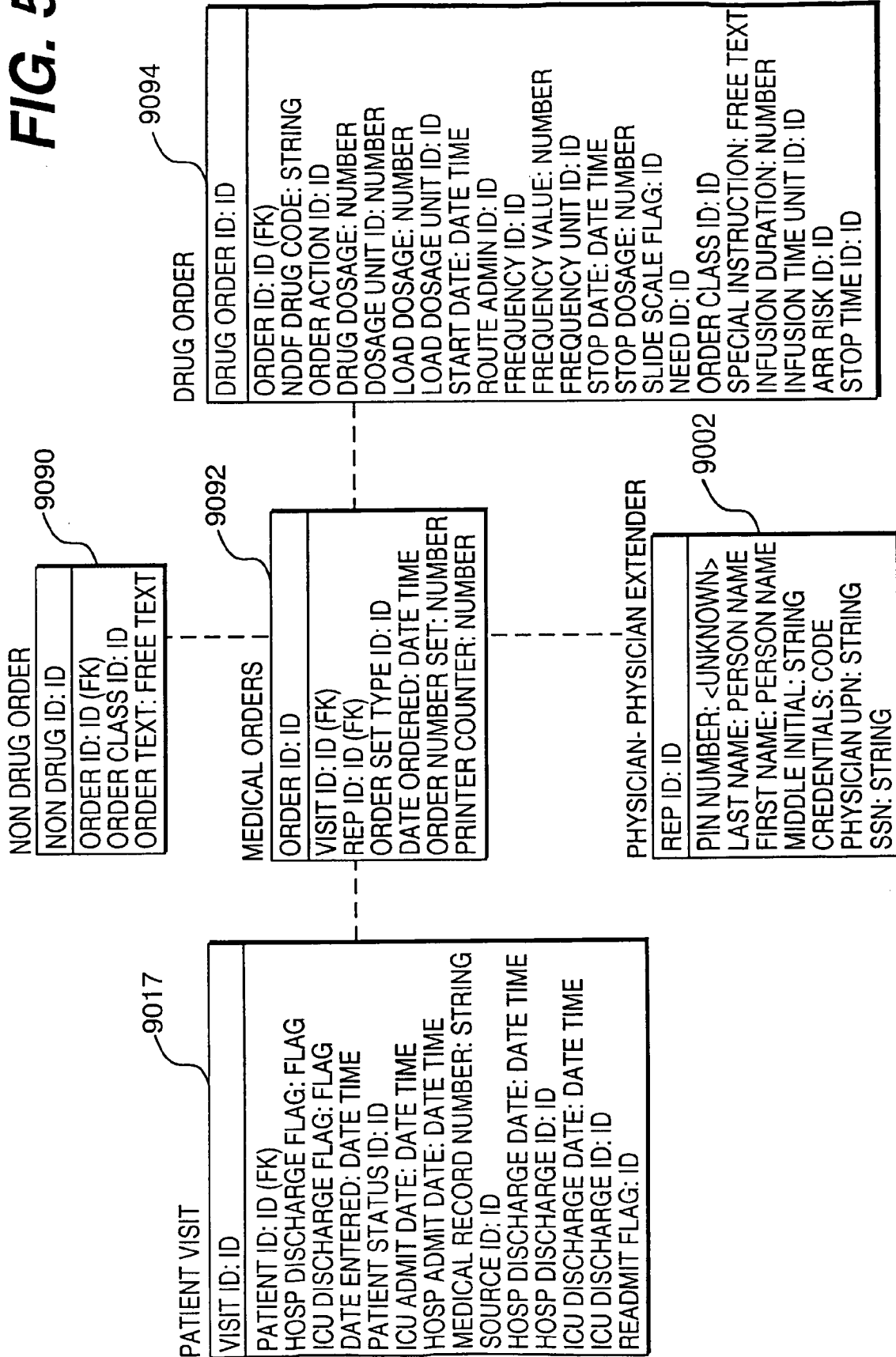




FIG. 5



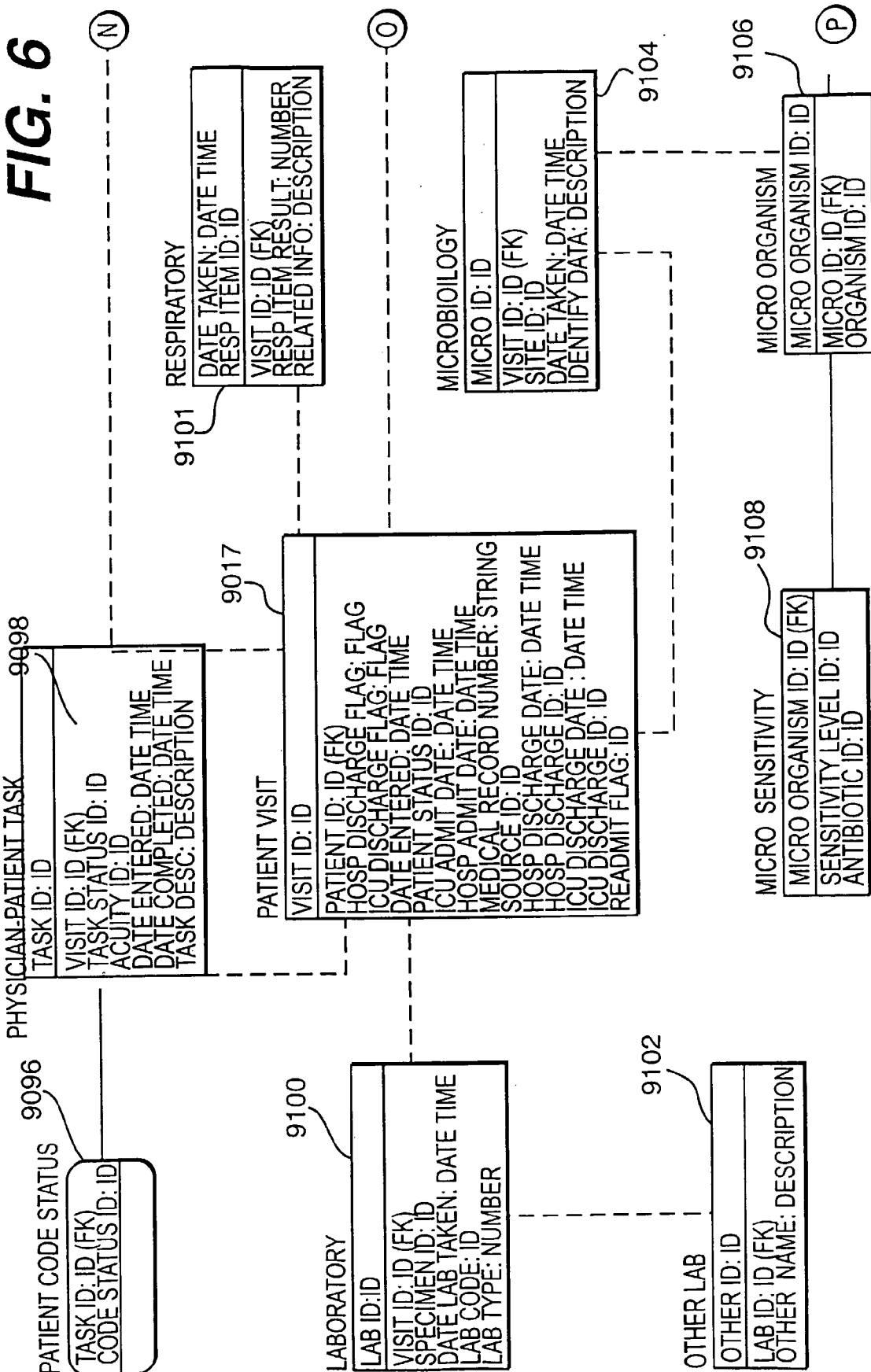
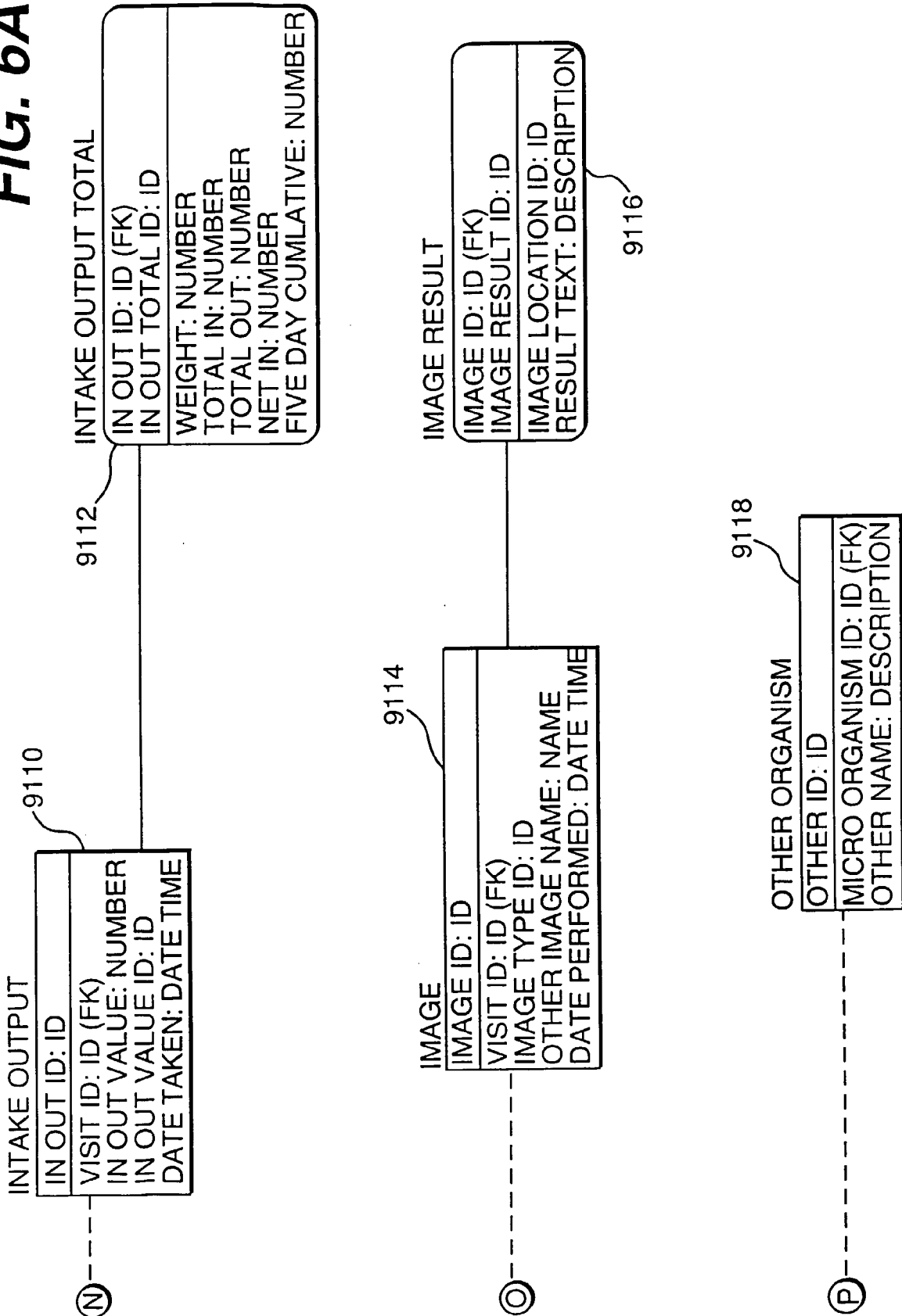


FIG. 6A



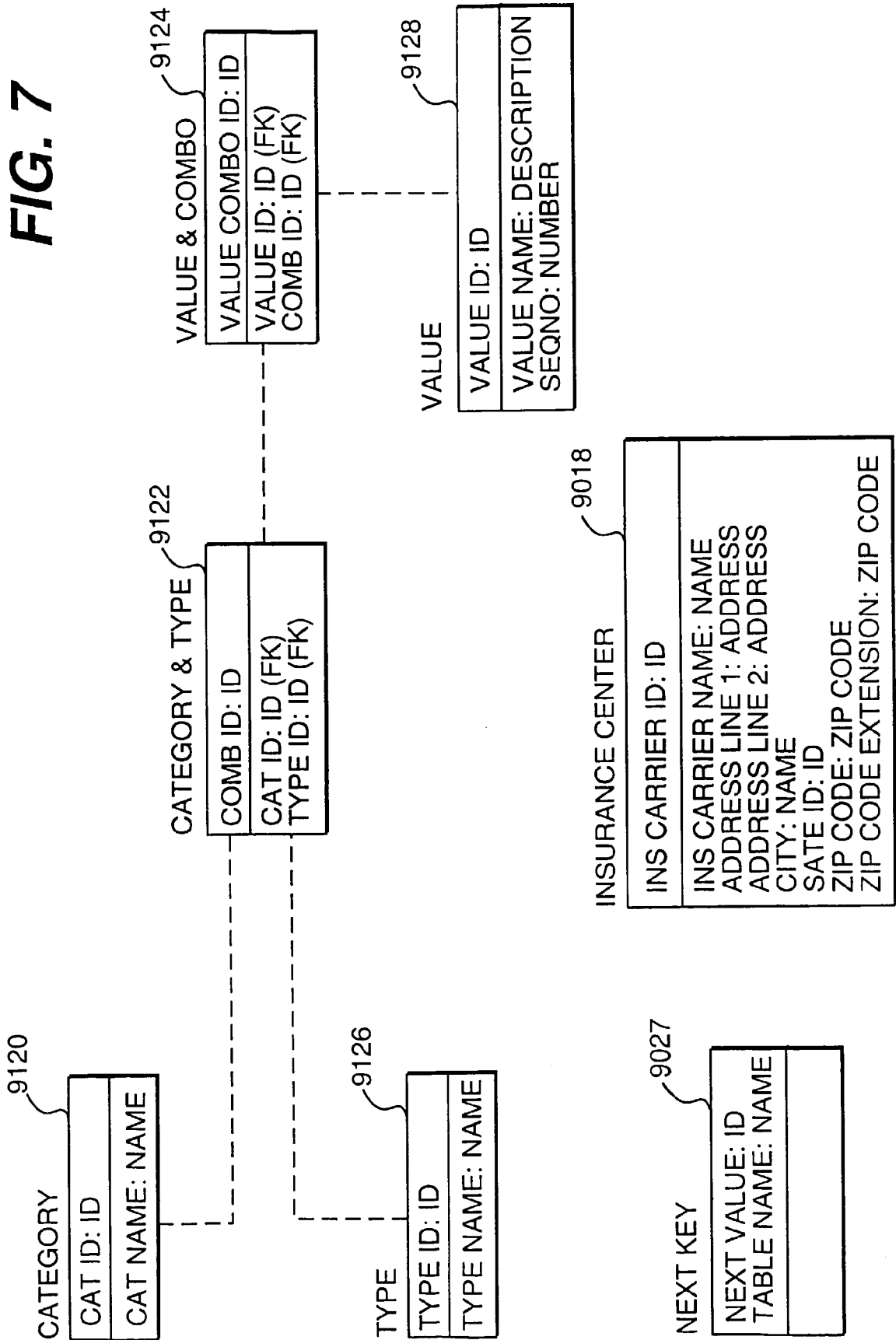


FIG. 8

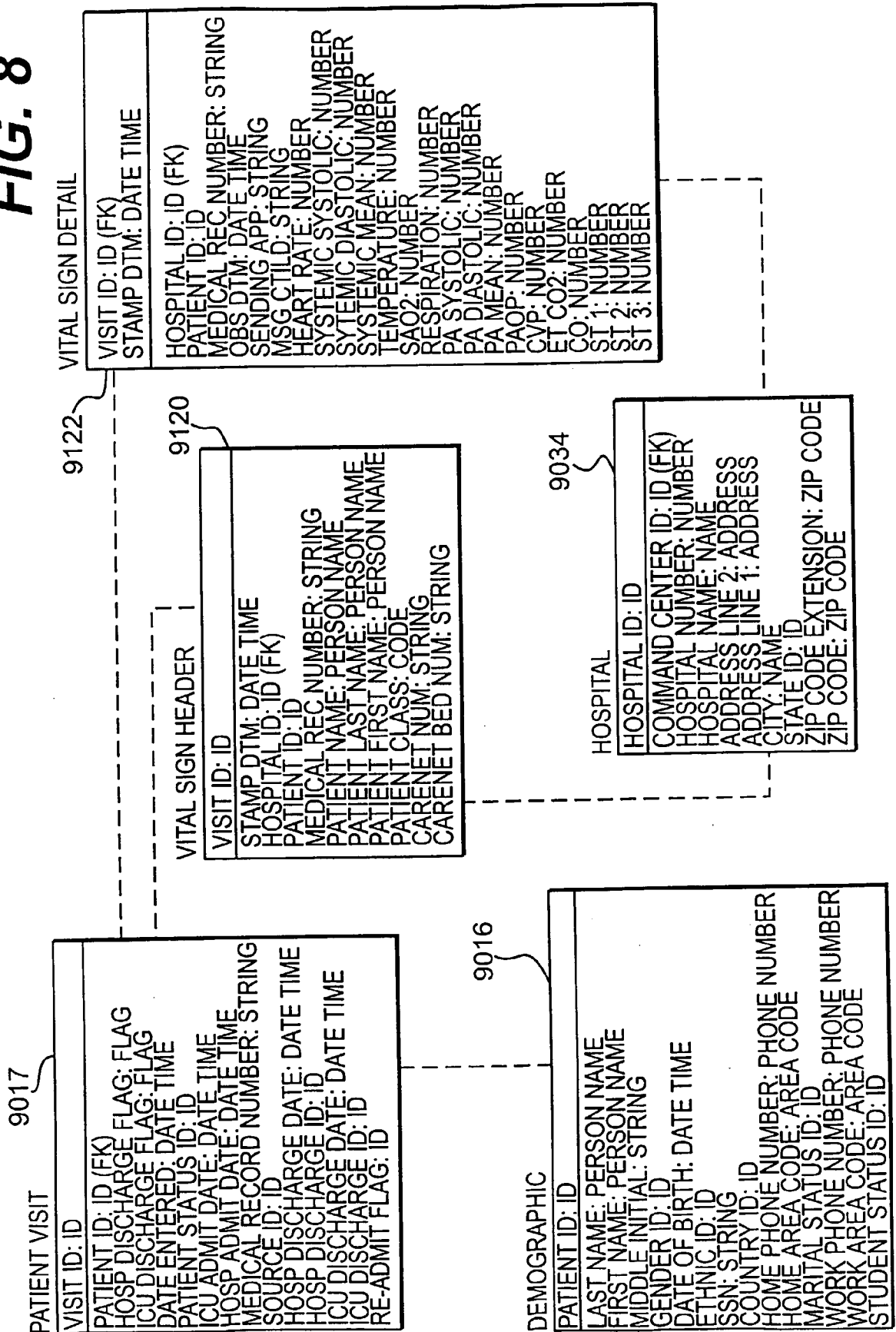
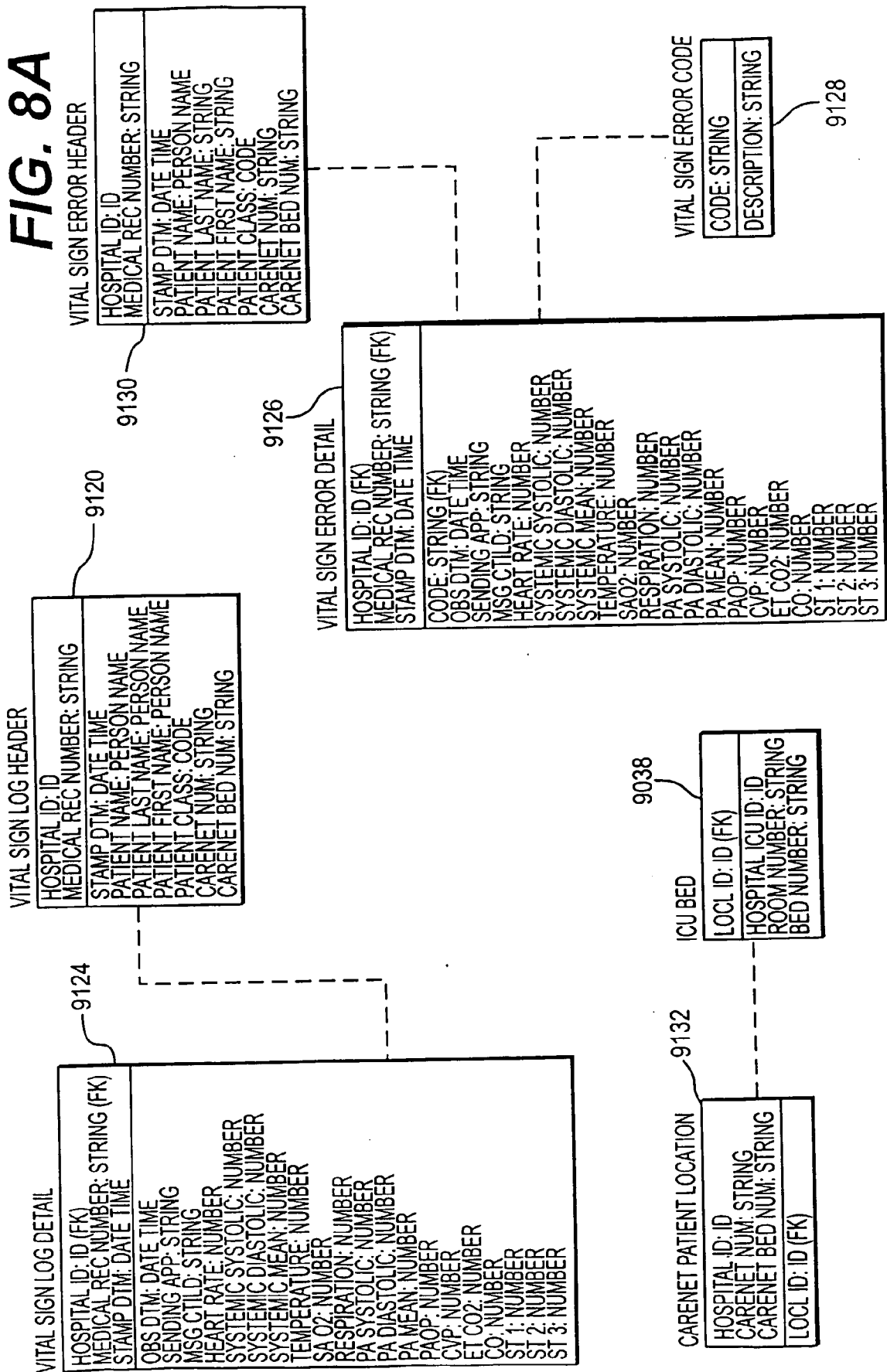
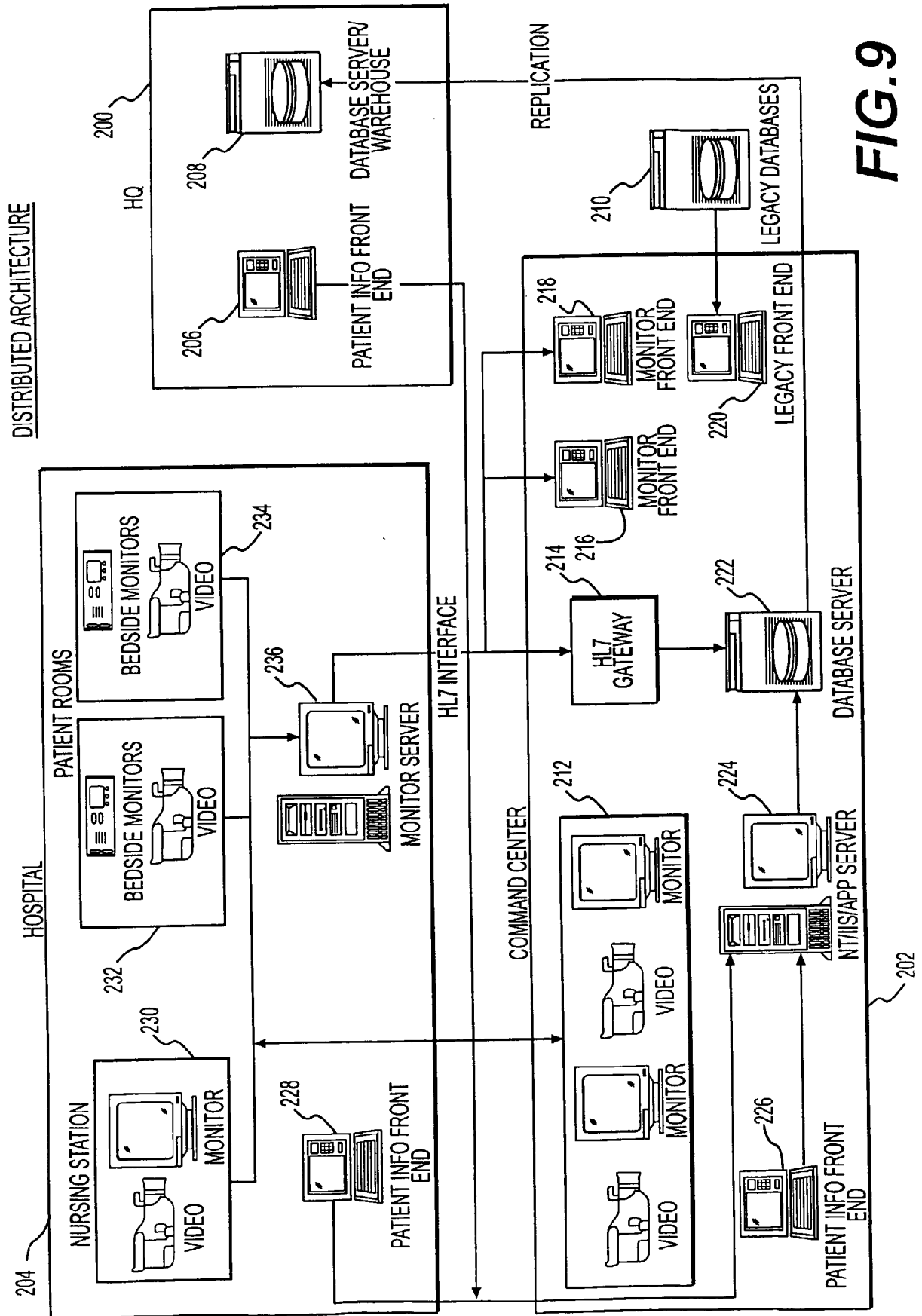


FIG. 8A





**FIG.9**

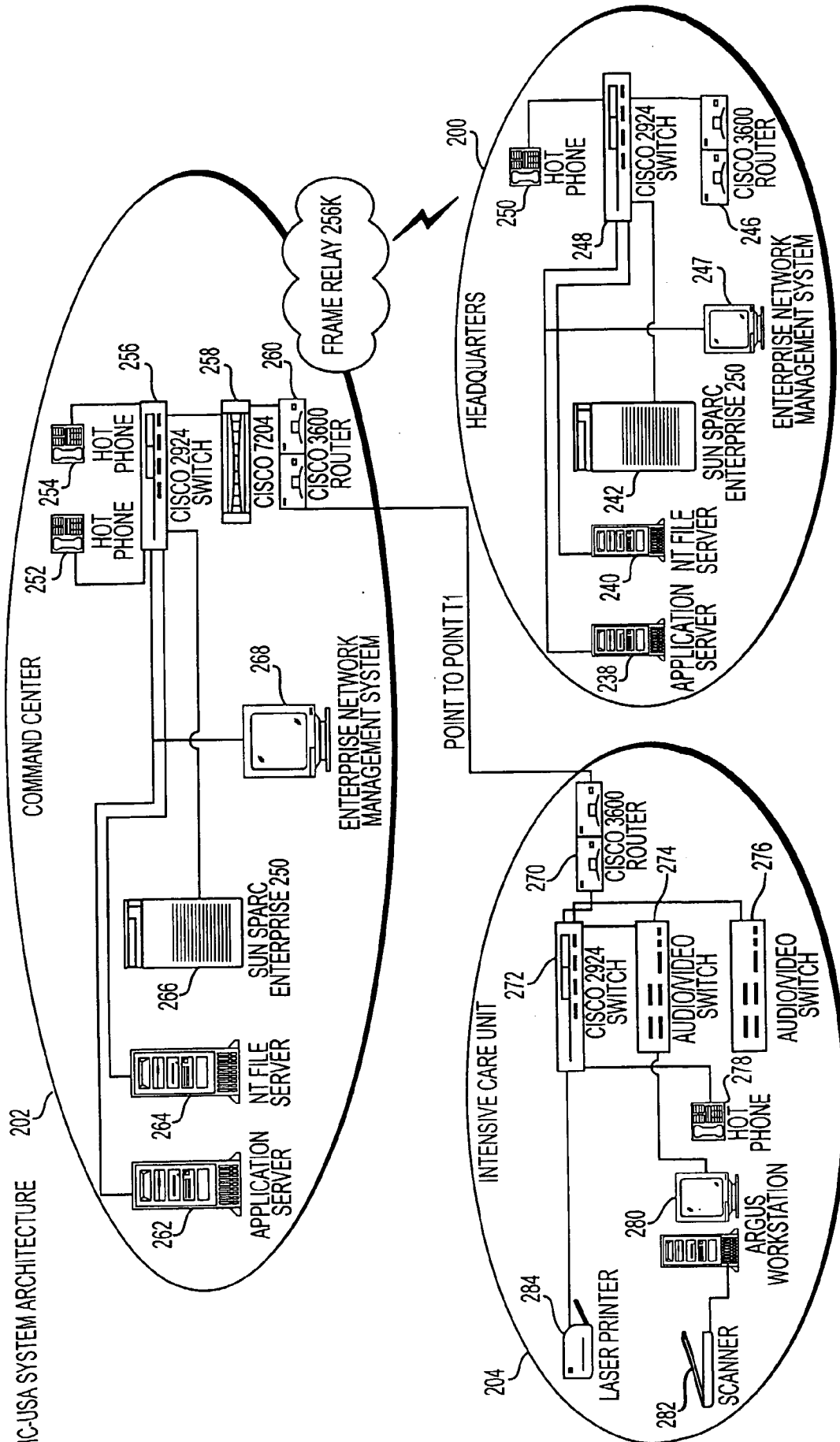
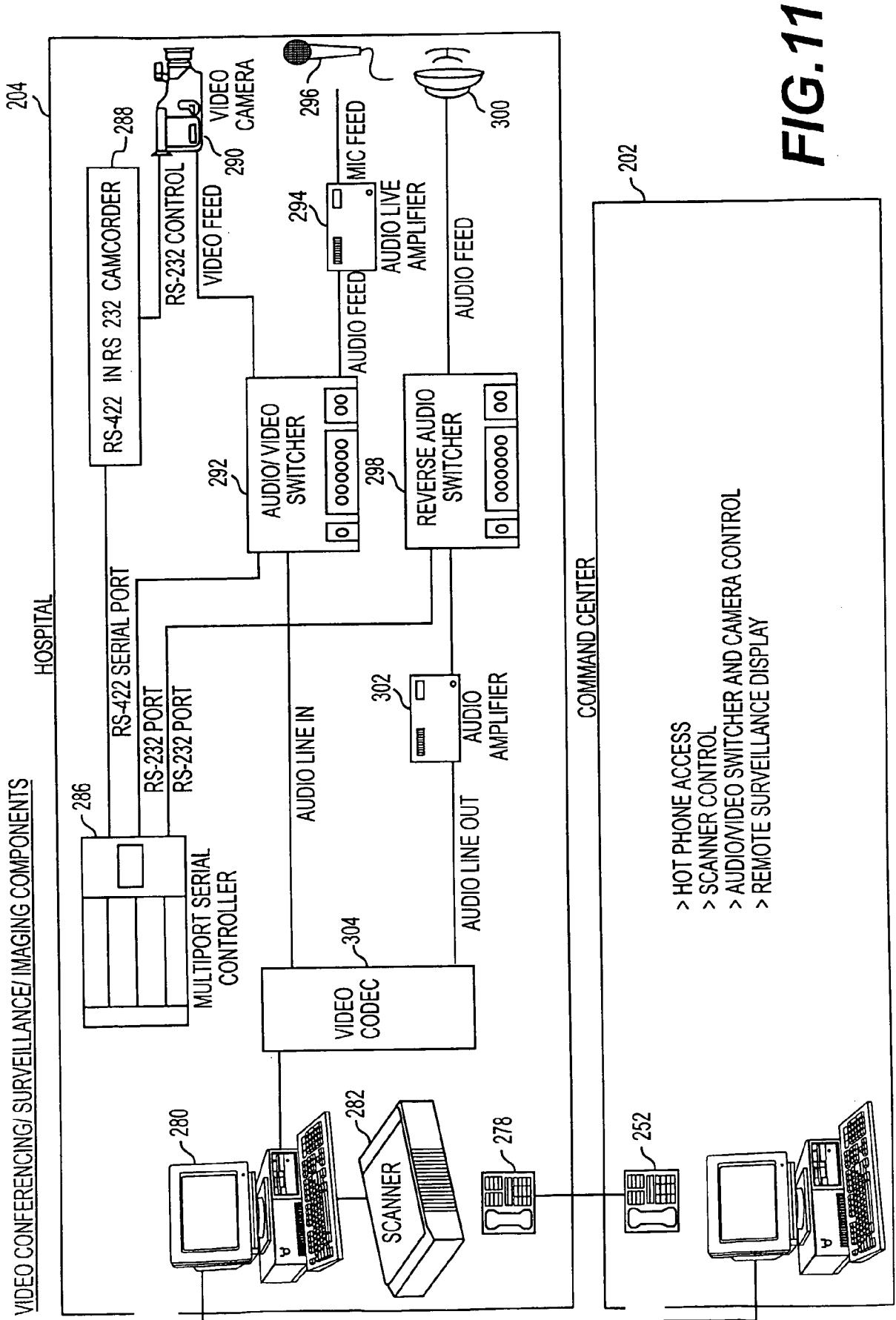
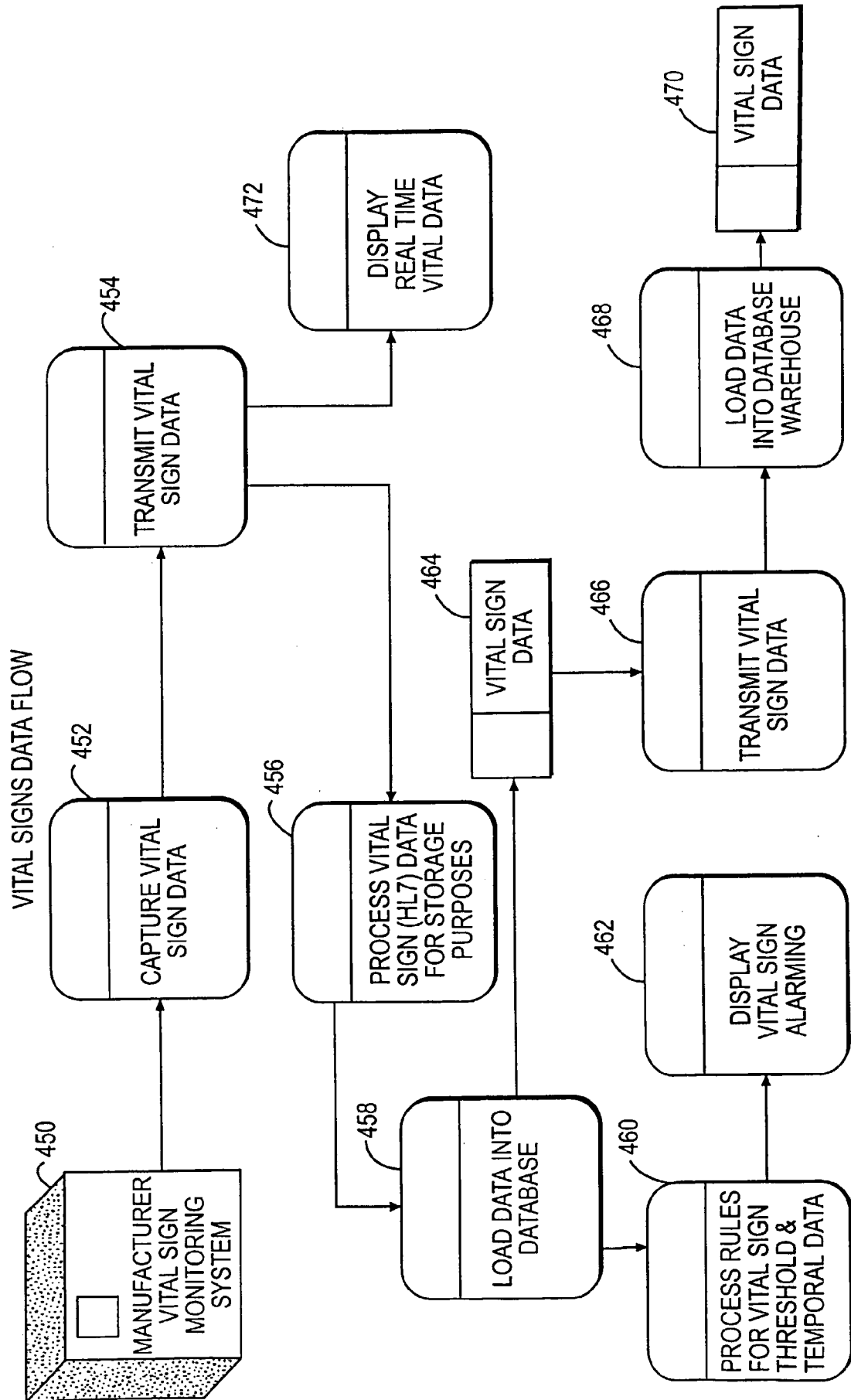


FIG. 10



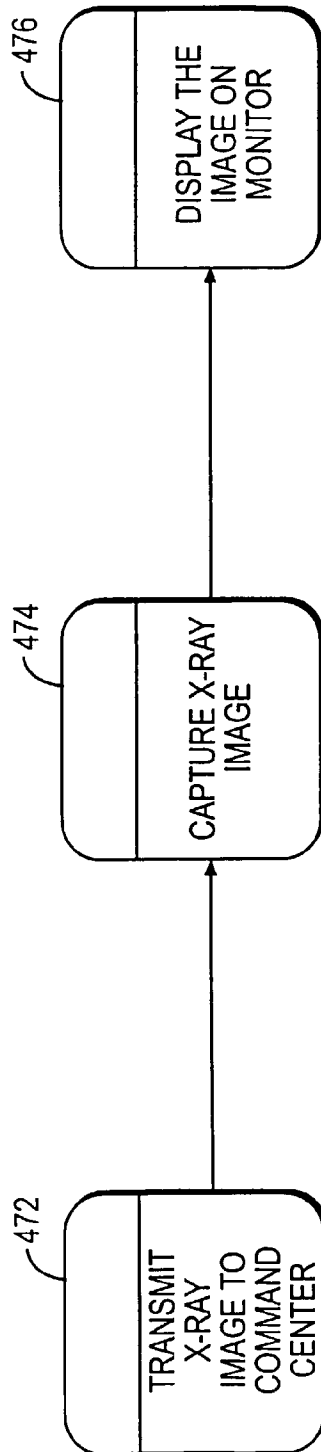


**FIG. 11**

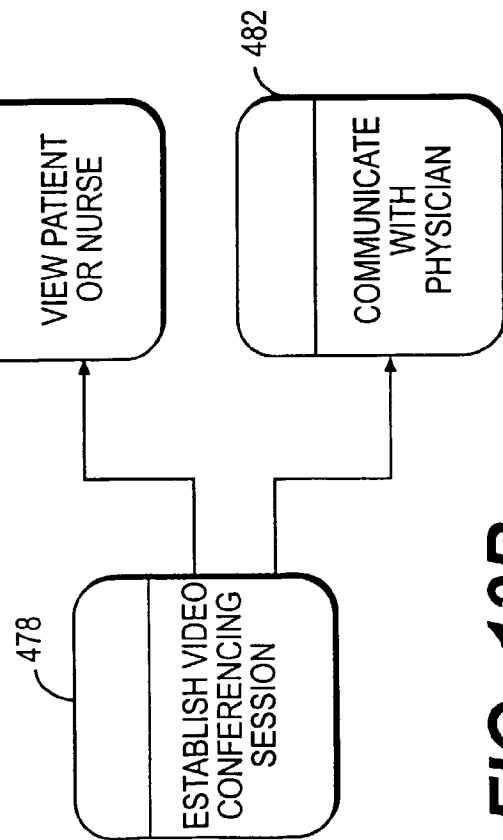


**FIG. 12**

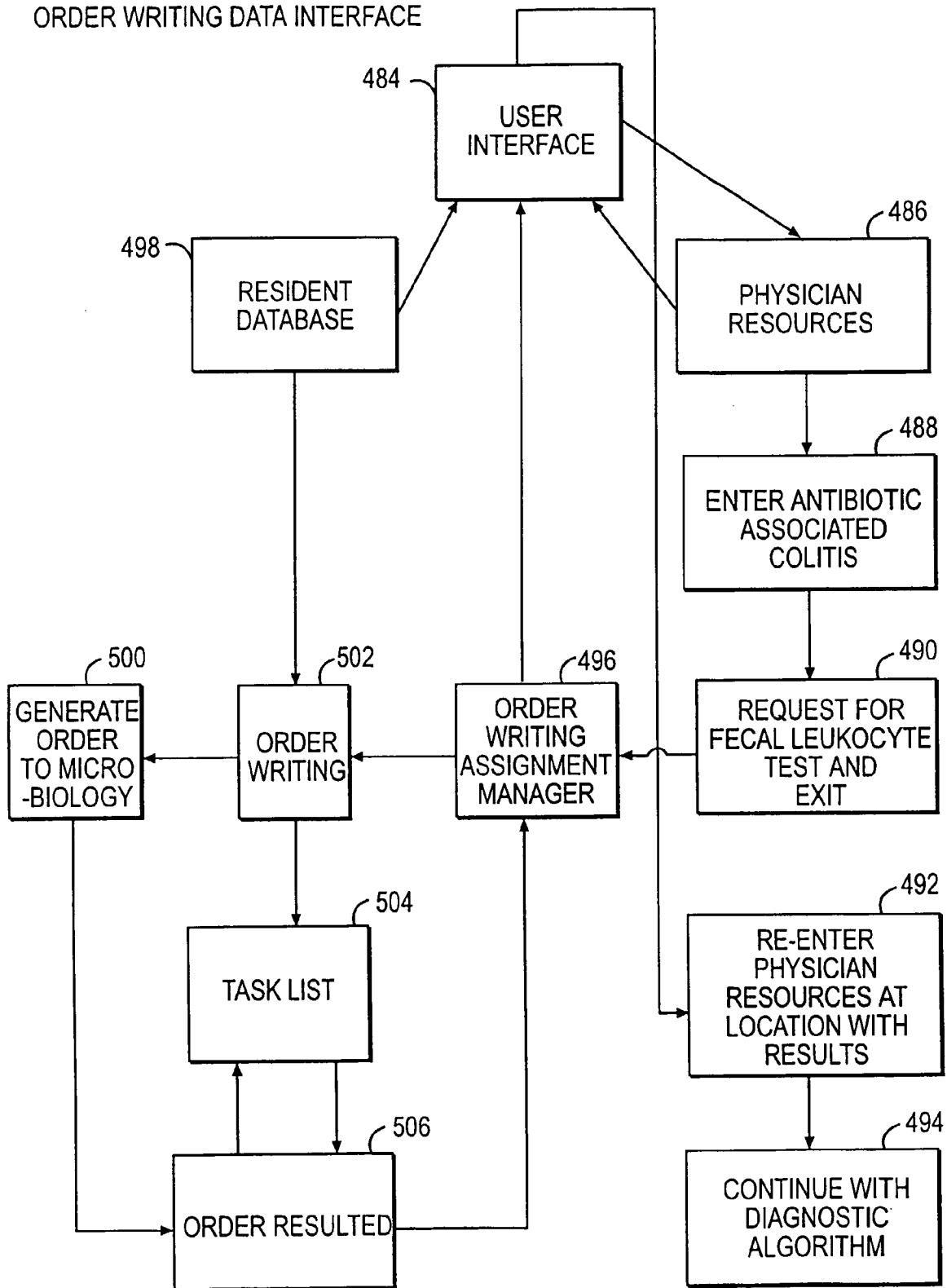
PATIENT INTERACTION DATA FLOW

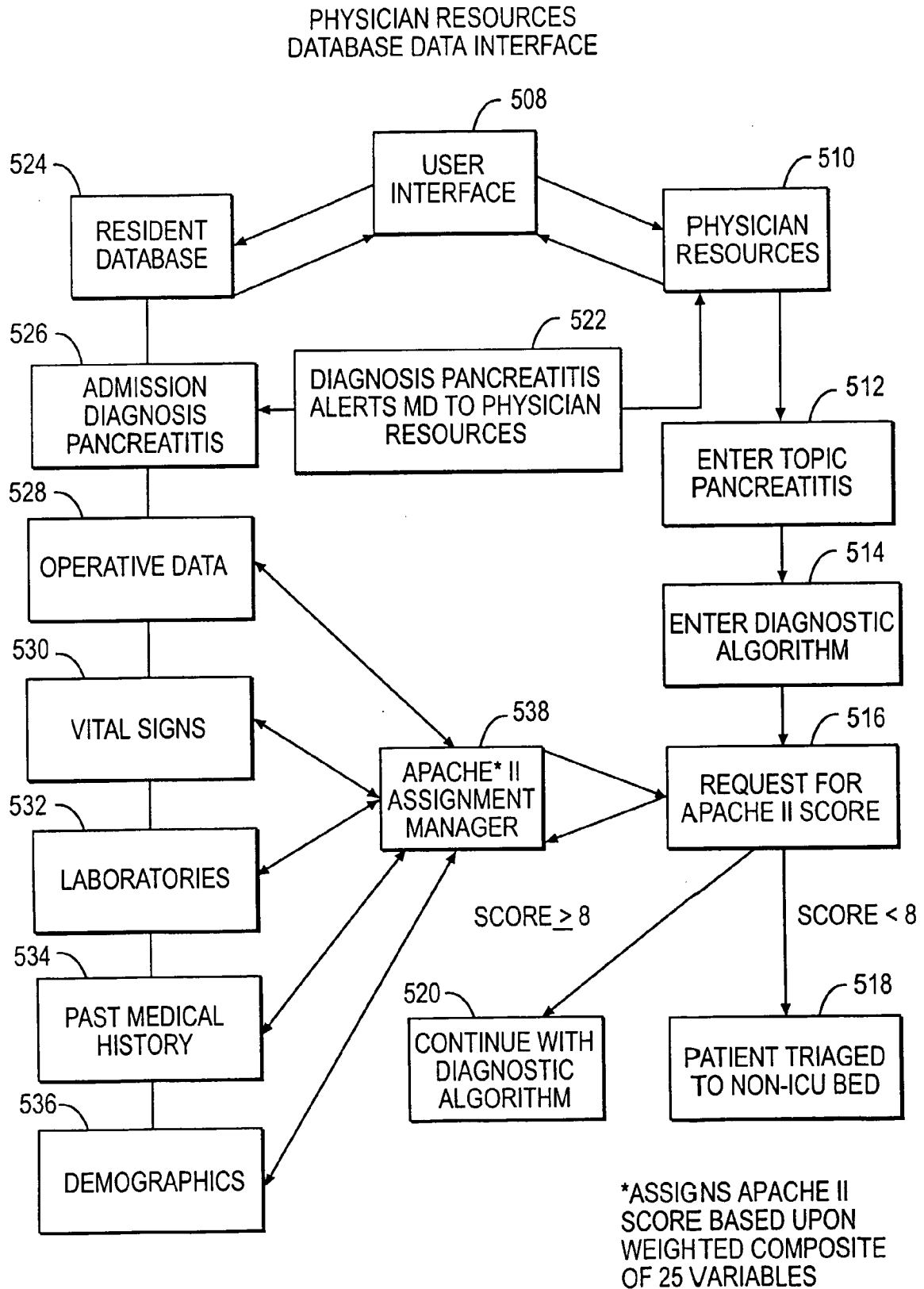


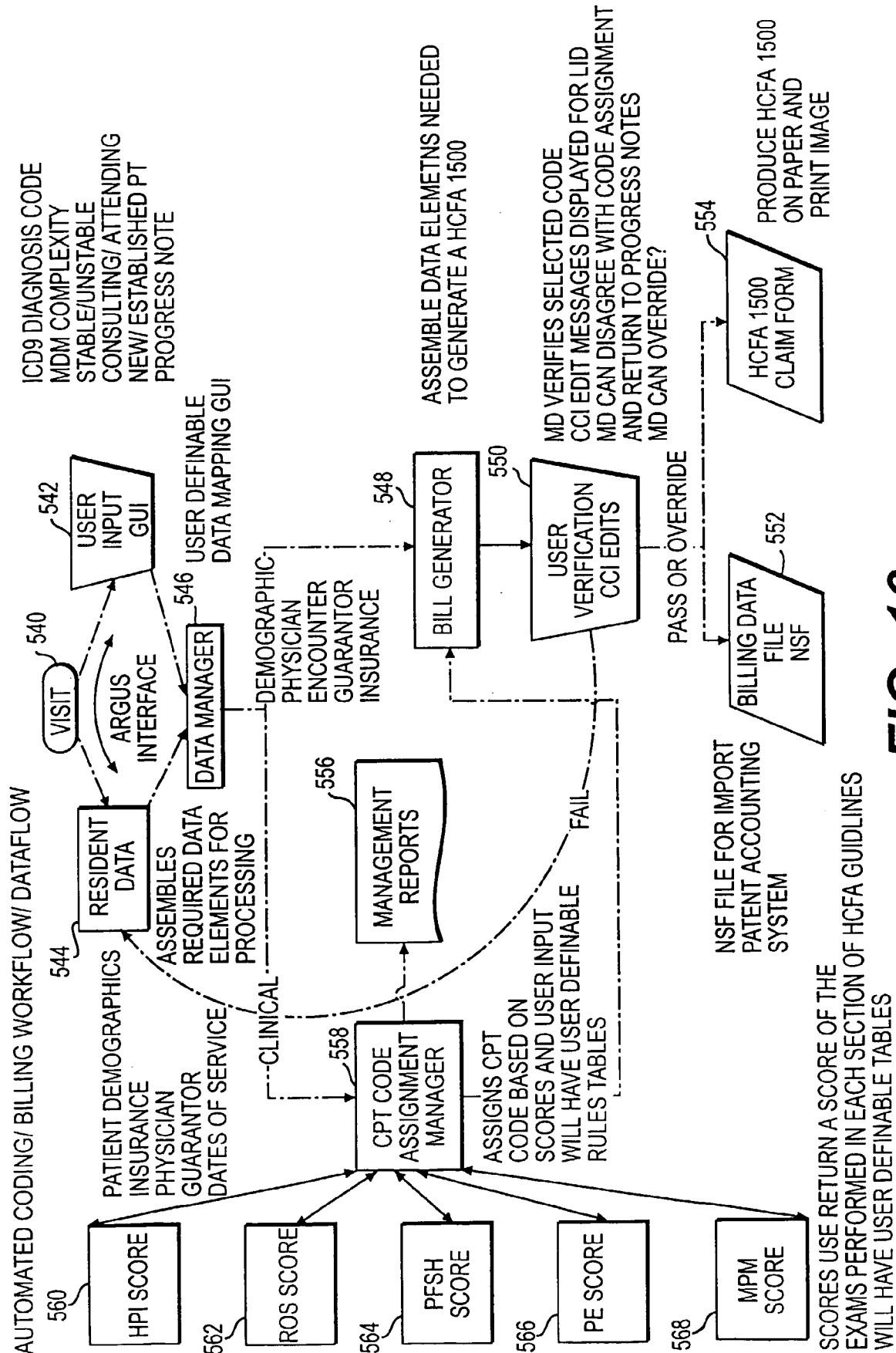
**FIG. 13A**



**FIG. 13B**

PHYSICIAN RESOURCES AND  
ORDER WRITING DATA INTERFACE**FIG. 14**

**FIG. 15**



**FIG. 16**

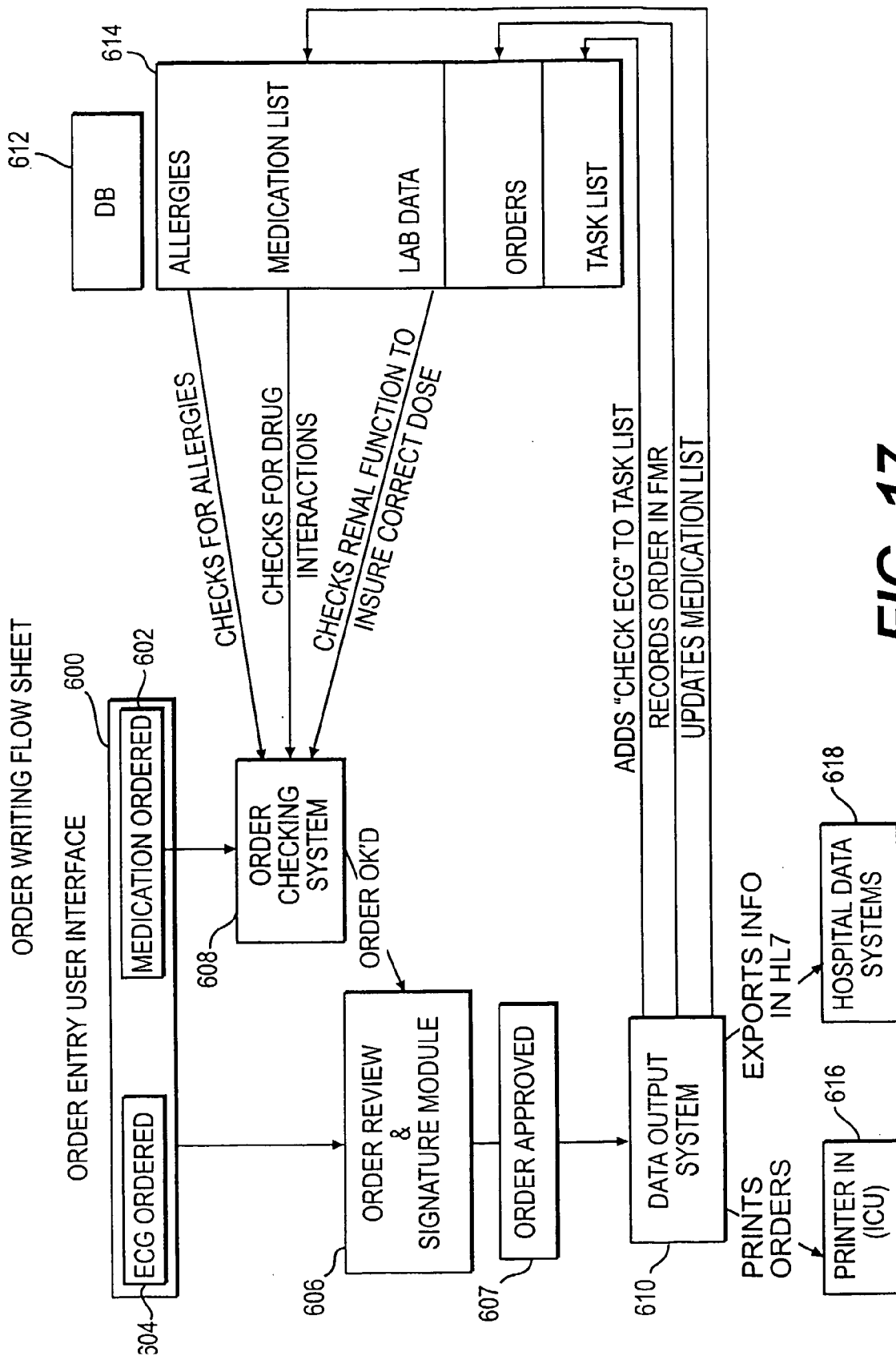
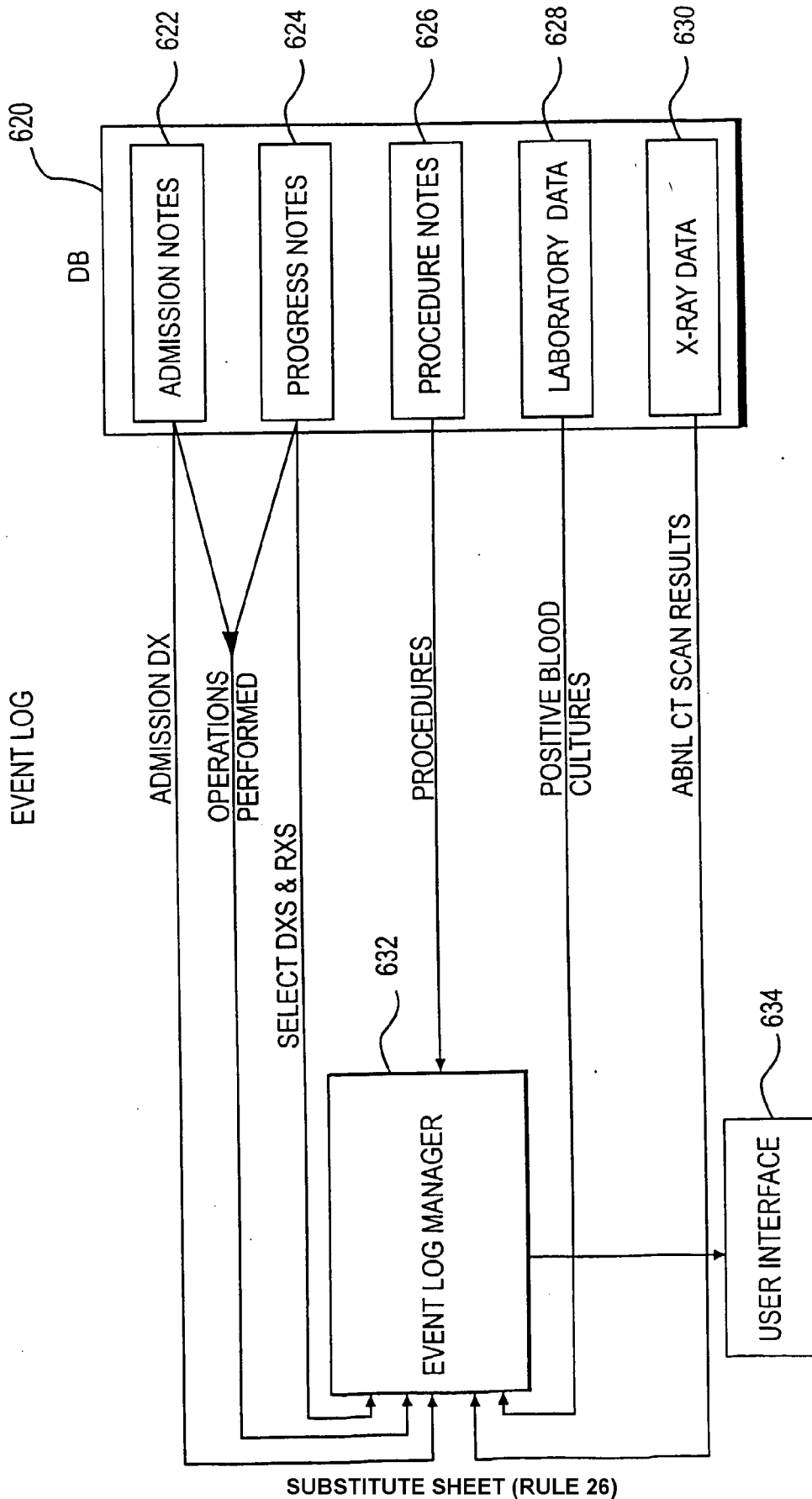


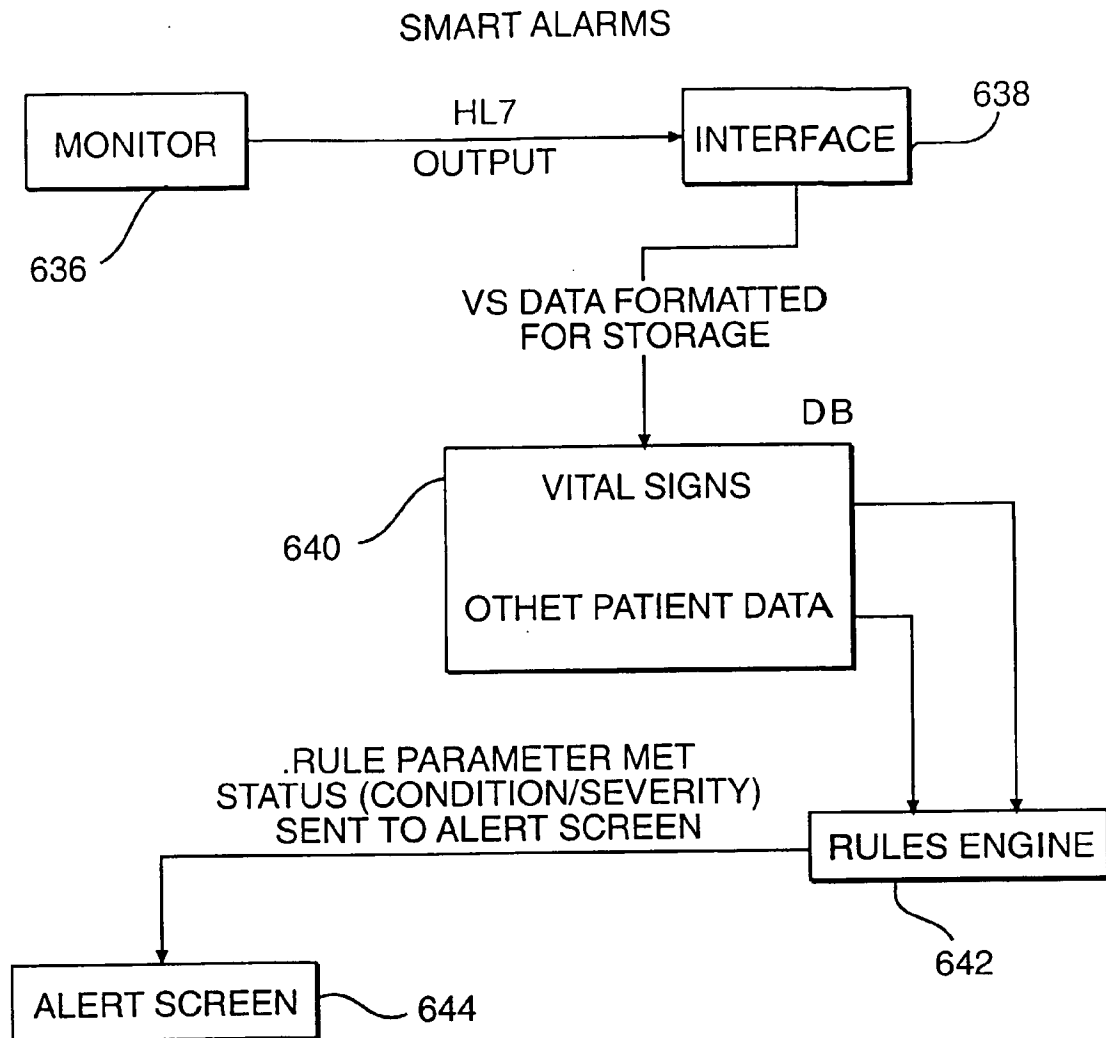
FIG. 17



**FIG. 18**

THE EVENT LOG PRESENTS IN A SINGLE LOCATION KEY CLINICAL INFORMATION FROM THROUGHOUT A PATIENT'S STAY IN THE ICU. THE EVENT LOG PROVIDES CARE GIVERS WITH A SNAPSHOT VIEW OF ALL SALIENT EVENTS SINCE ADMISSION. ALL RELEVANT DATA ARE PRESENTED CHRONOLOGICALLY.





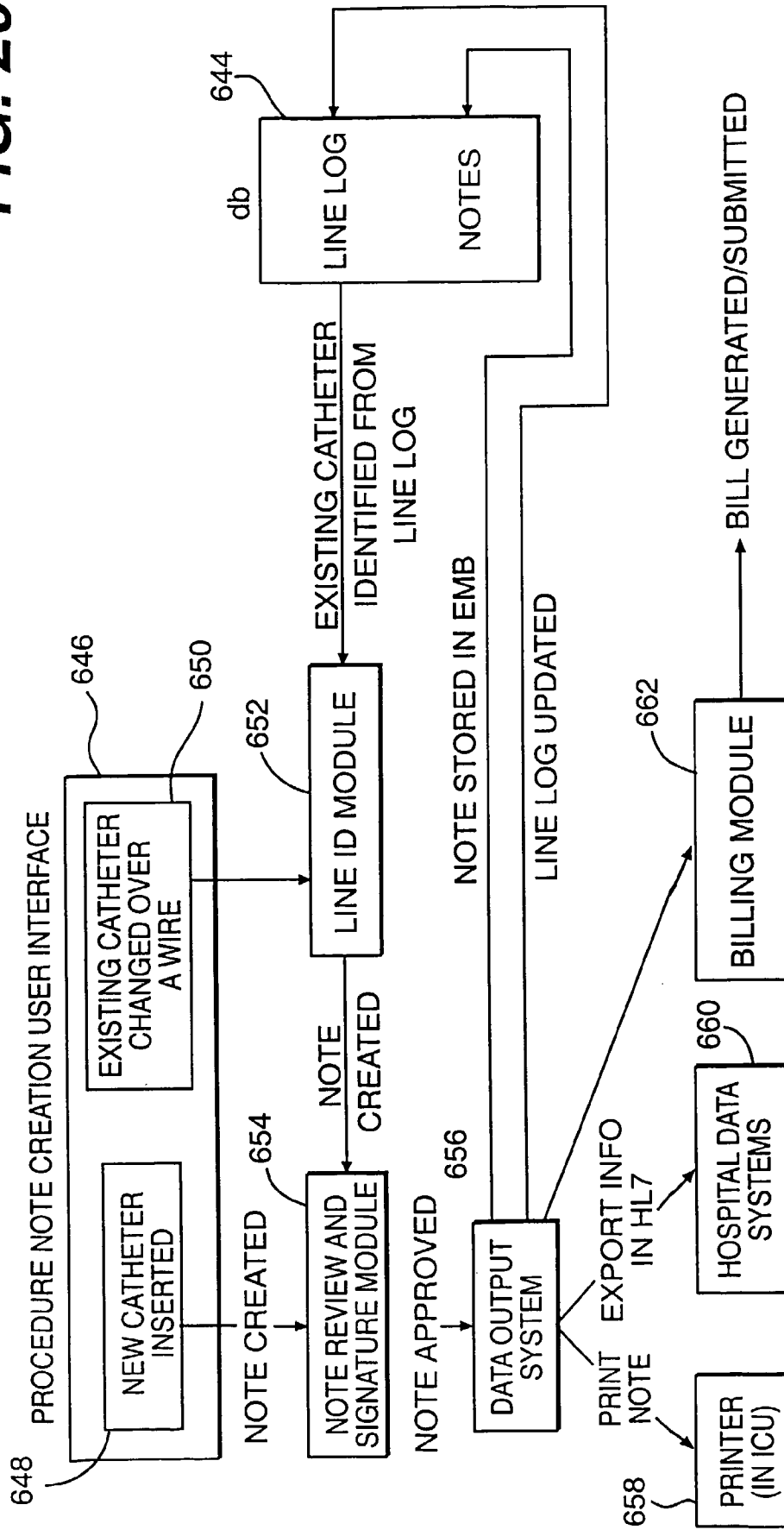
THE SMART ALARM SYSTEM CONSTANTLY MONITORS PHYSIOLOGIC DATA (COLLECTED ONCE A MINUTE FROM THE BEDSIDE MONITORS) AND OTHER CLINICAL INFORMATION. THE RULES ENGINE SEARCHES FOR PATTERNS OF DATA INDICATIVE OF CLINICAL DETERIORATION. EXAMPLES INCLUDE CHANGES IN VITAL SIGNS OVER TIME (e.g. A 25% INCREASE IN THE HR AND A 20% DECREASE IN BP), PARALLEL REDUCTIONS IN URINE OUTPUT AND CENTRAL VENOUS PRESSURE THAT SUGGEST DEVELOPING HYPOVOLEMIA, AND PROGRESSIVE REDUCTIONS IN HEMOGLOBIN CONCENTRATION OVER TIME THAT INDICATE A NEED TO EXCLUDE ACTIVE BLEEDING (AND A POSSIBLE NEED TO ADMINISTER BLOOD). WHEN RULE CONDITIONS ARE MET, RELEVANT INFORMATION IS DISPLAYED ON THE SYSTEM "ALERT SCREEN".

THE RATIONALE UNDERLYING SMART ALARMS IS TO FACILITATE DETECTION OF IMPENDING PROBLEMS AND TO AUTOMATE PROBLEM DETECTION. THE SYSTEM BALANCES ALARM SENSITIVITY AND SPECIFICITY IN ORDER TO MAXIMIZE THE BENEFIT OF THE ALARMS TO THE INTENSIVIST.

**FIG. 19**

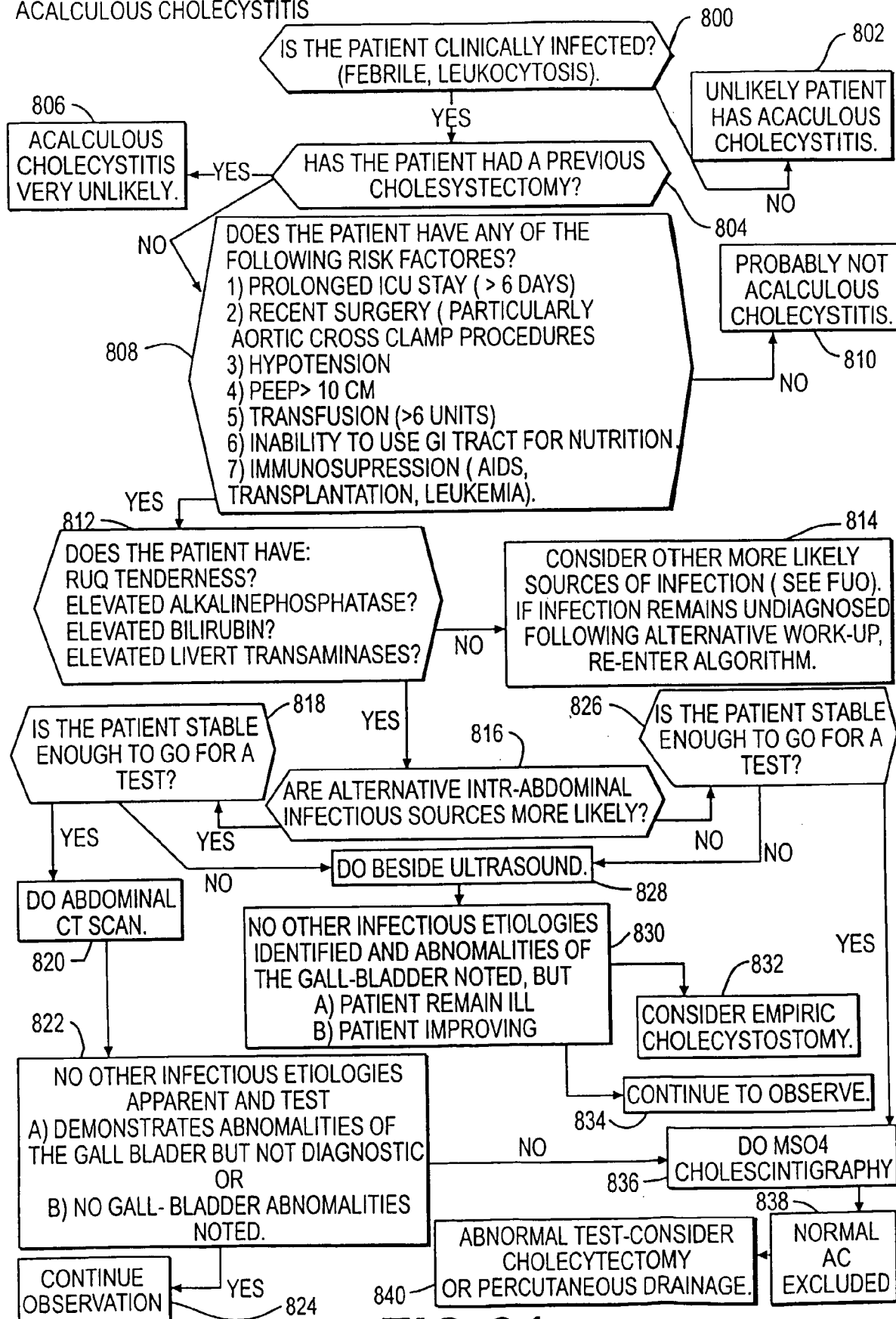
FIG. 20

PROCEDURE NOTE - LINE LOG

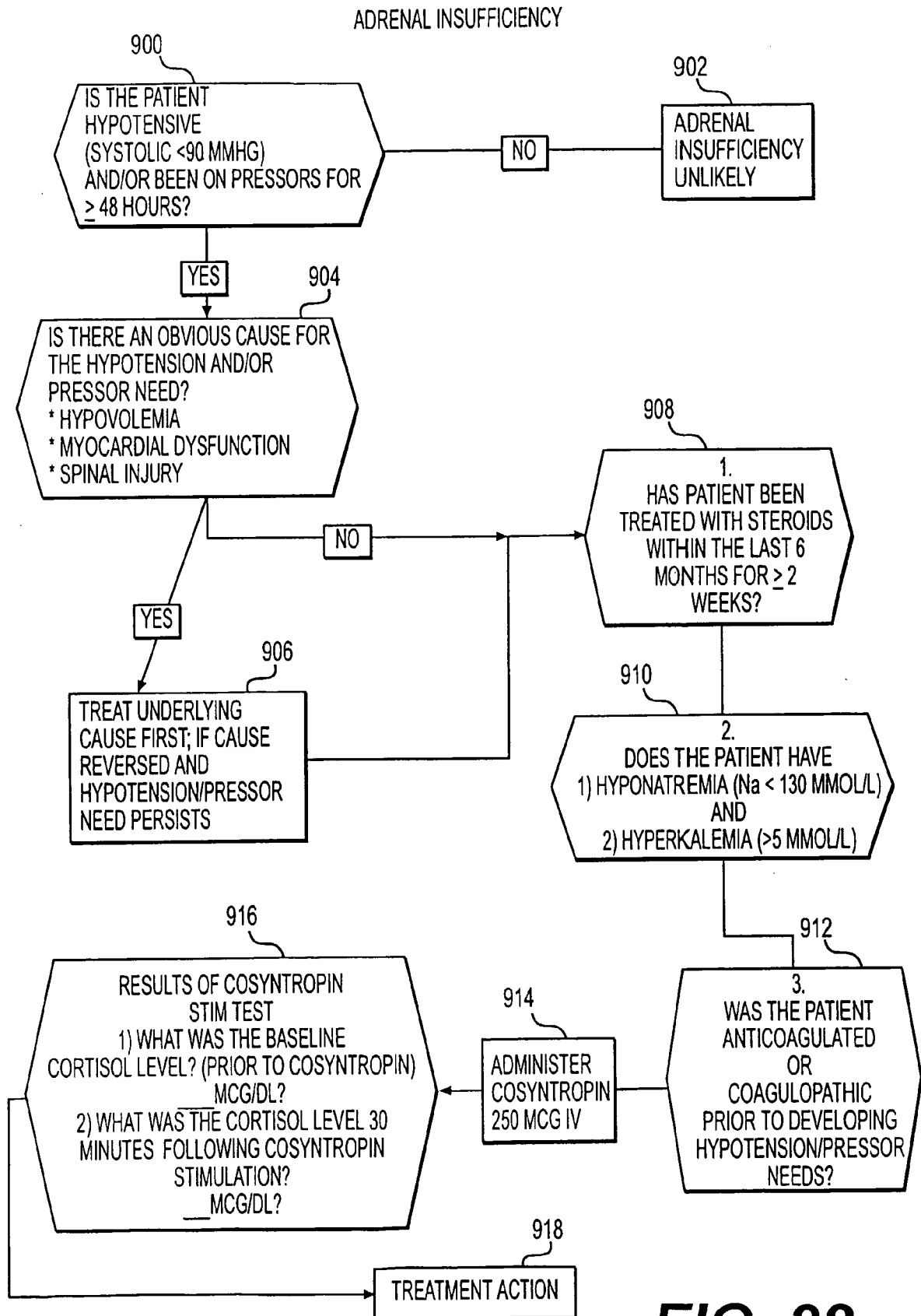


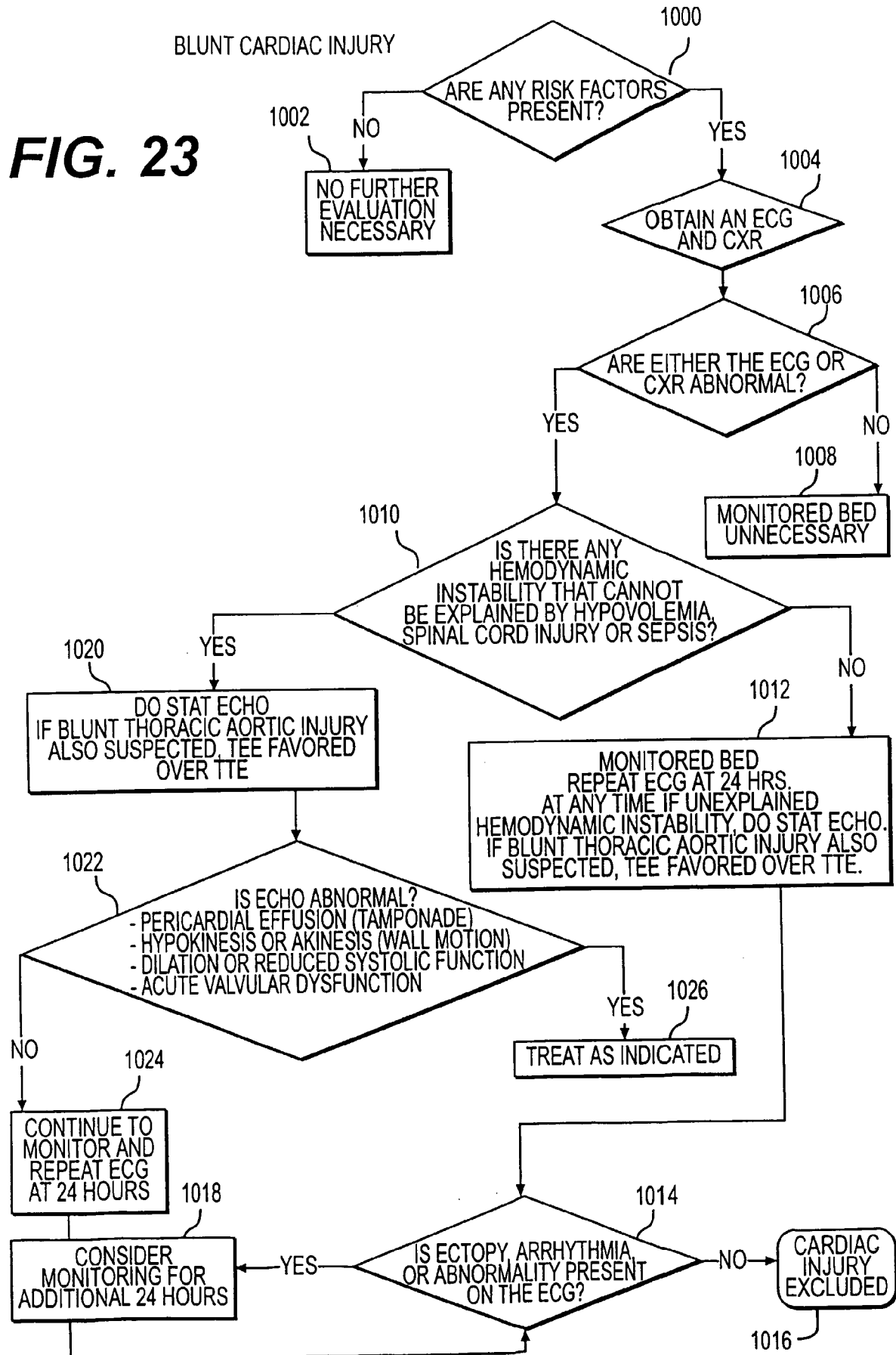
THE LINE LOG CONTAINS, FOR EACH PATIENT, RELEVANT INFORMATION ABOUT ALL INDWELLING CATHETERS, INCLUDING TYPE AND LOCATION OF CATHETER, INSERTION DATE, THE MOST RECENT DATE THAT THE CATHETER WAS CHANGED OVER A WIRE, AND THE DATE THE CATHETER WAS REMOVED. THIS INFORMATION HELPS CLINICIANS EVALUATE THE LIKELIHOOD THAT A GIVEN CATHETER IS INFECTED AND GUIDES MANAGEMENT.

## ACALCULOUS CHOLECYSTITIS



**FIG. 21**

**FIG. 22**

**FIG. 23**

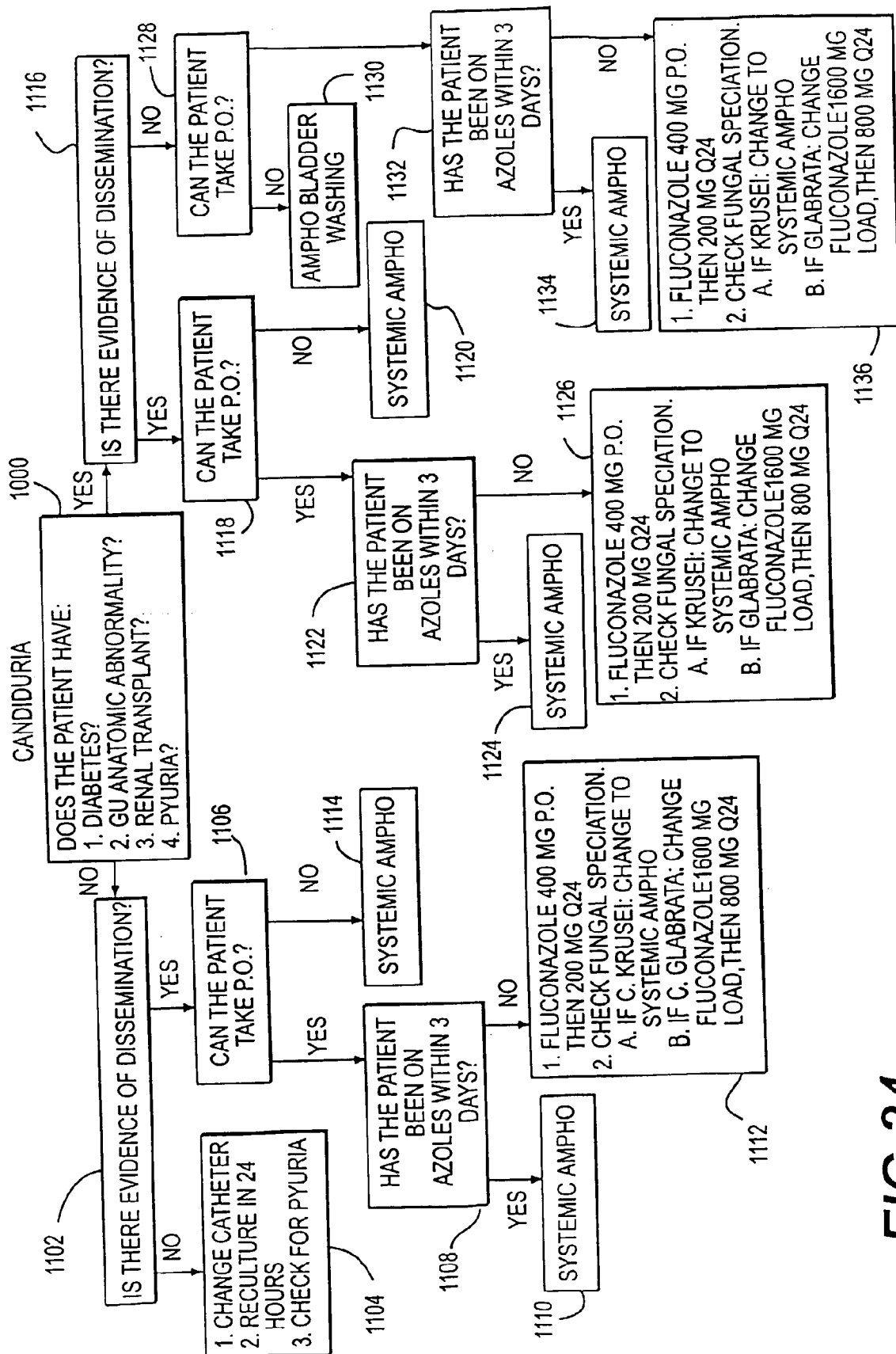
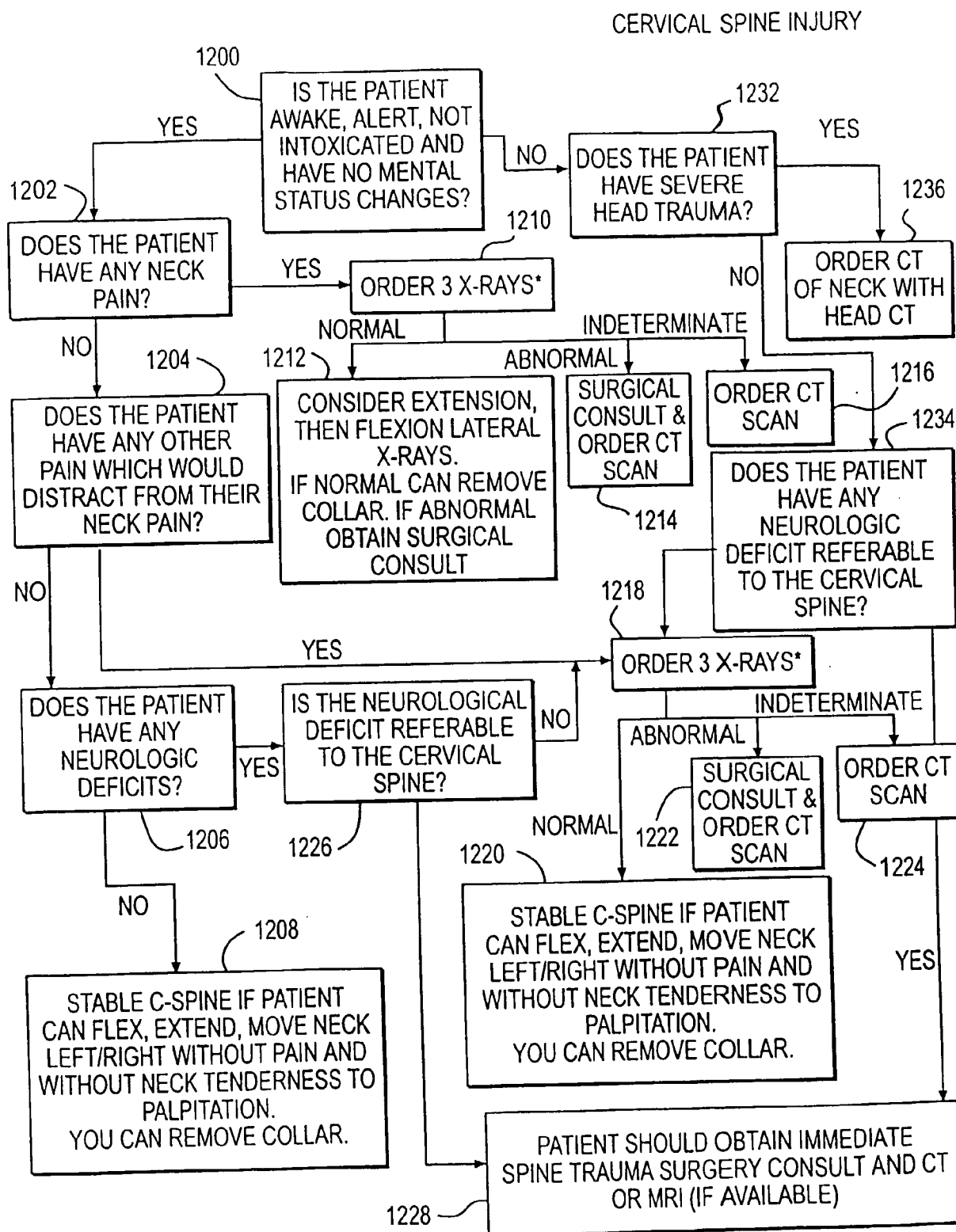


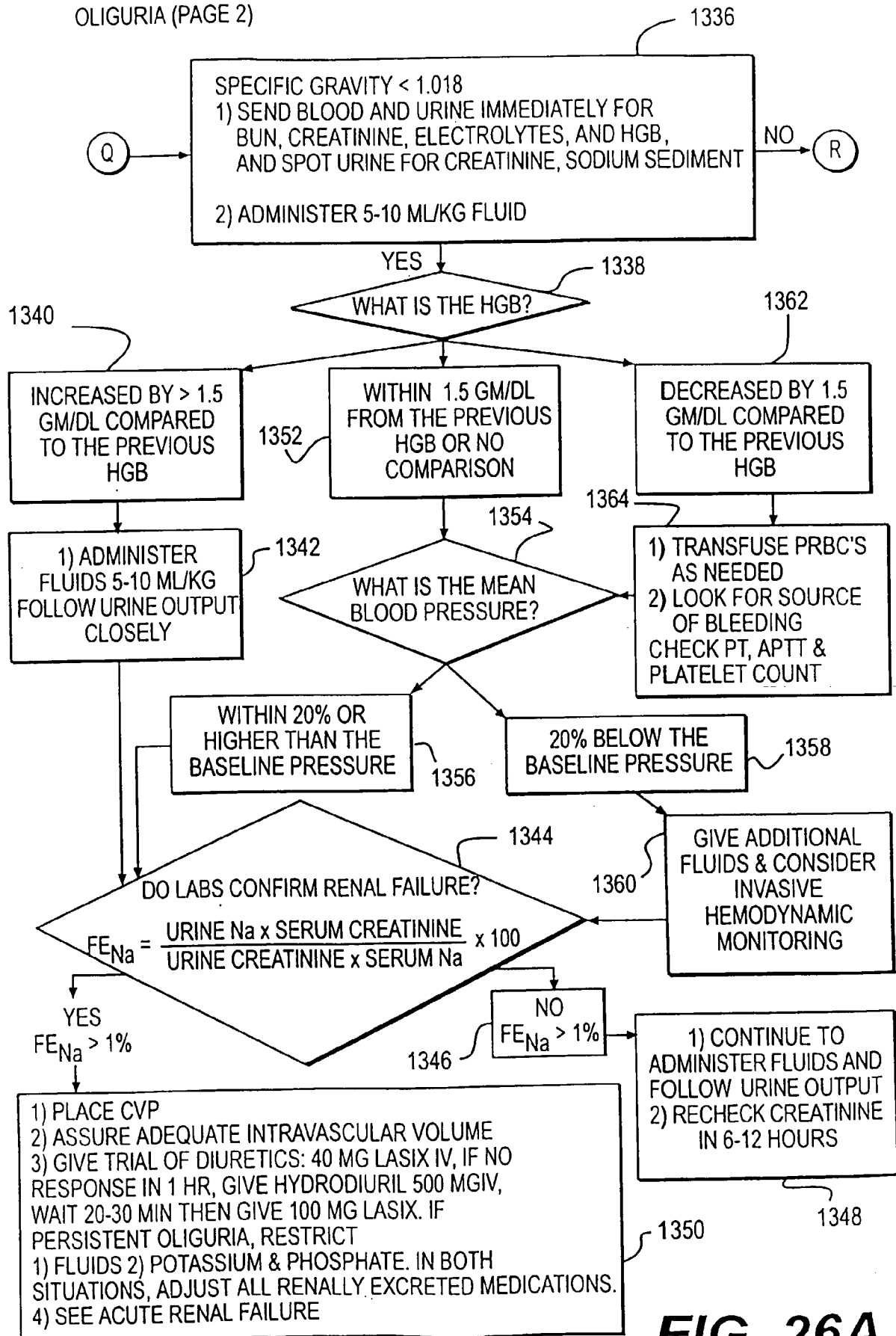
FIG. 24



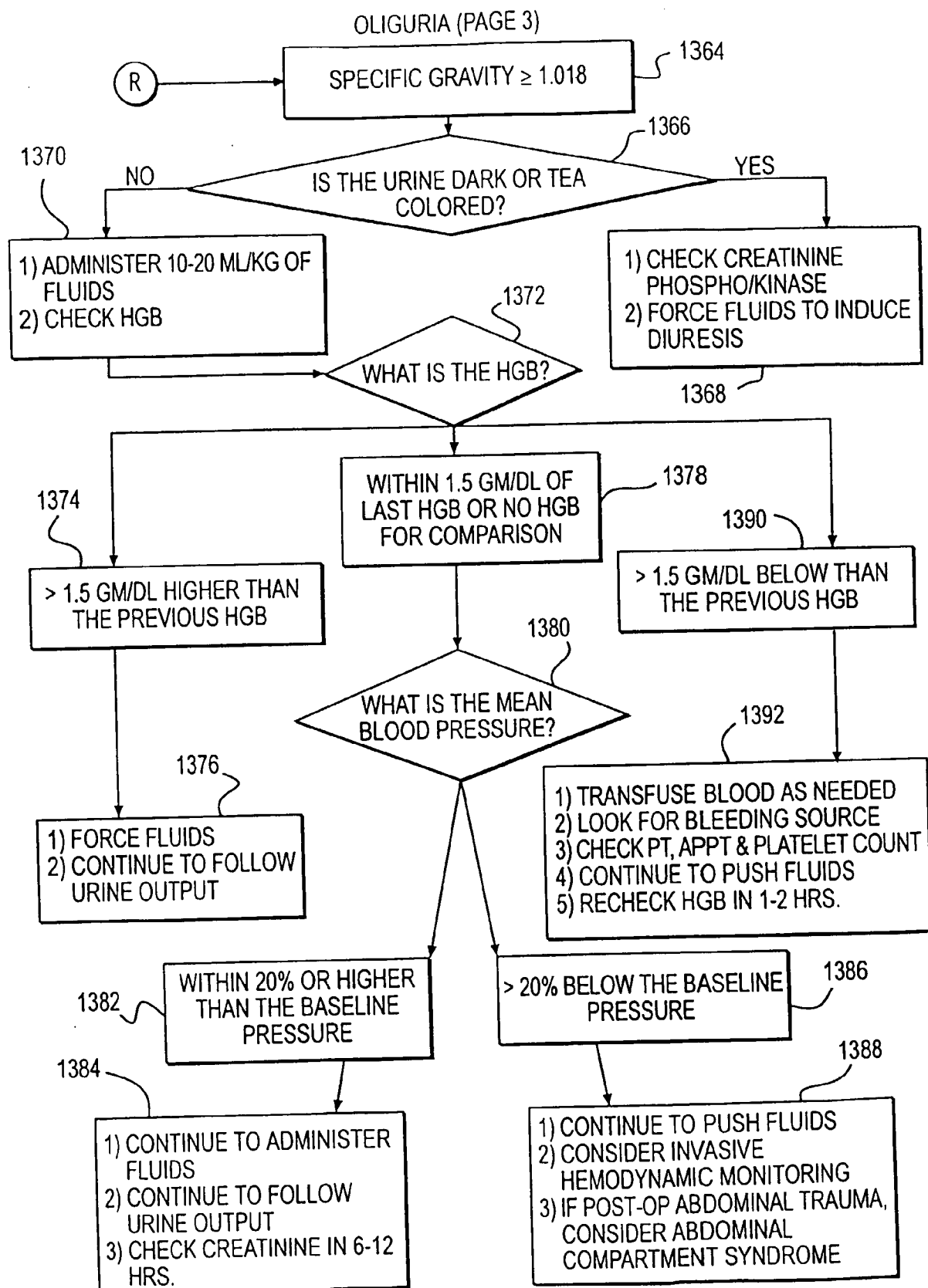
- \* 1) LATERAL VIEW REVEALING THE BASE OF THE OCCIPUT TO THE UPPER BORDER OF THE FIRST THORACIC VERTEBRA,  
 2) ANTEROPOSTERIOR VIEW REVEALING SPINOUS PROCESSES OF THE SECOND CERVICAL THROUGH THE FIRST THORACIC VERTEBRA, AND  
 3) AN OPEN MOUTH ODONTOID VIEW REVEALING THE LATERAL MASSES OF THE FIRST CERVICAL VERTEBRA AND ENTIRE ODONTOID PROCESS.

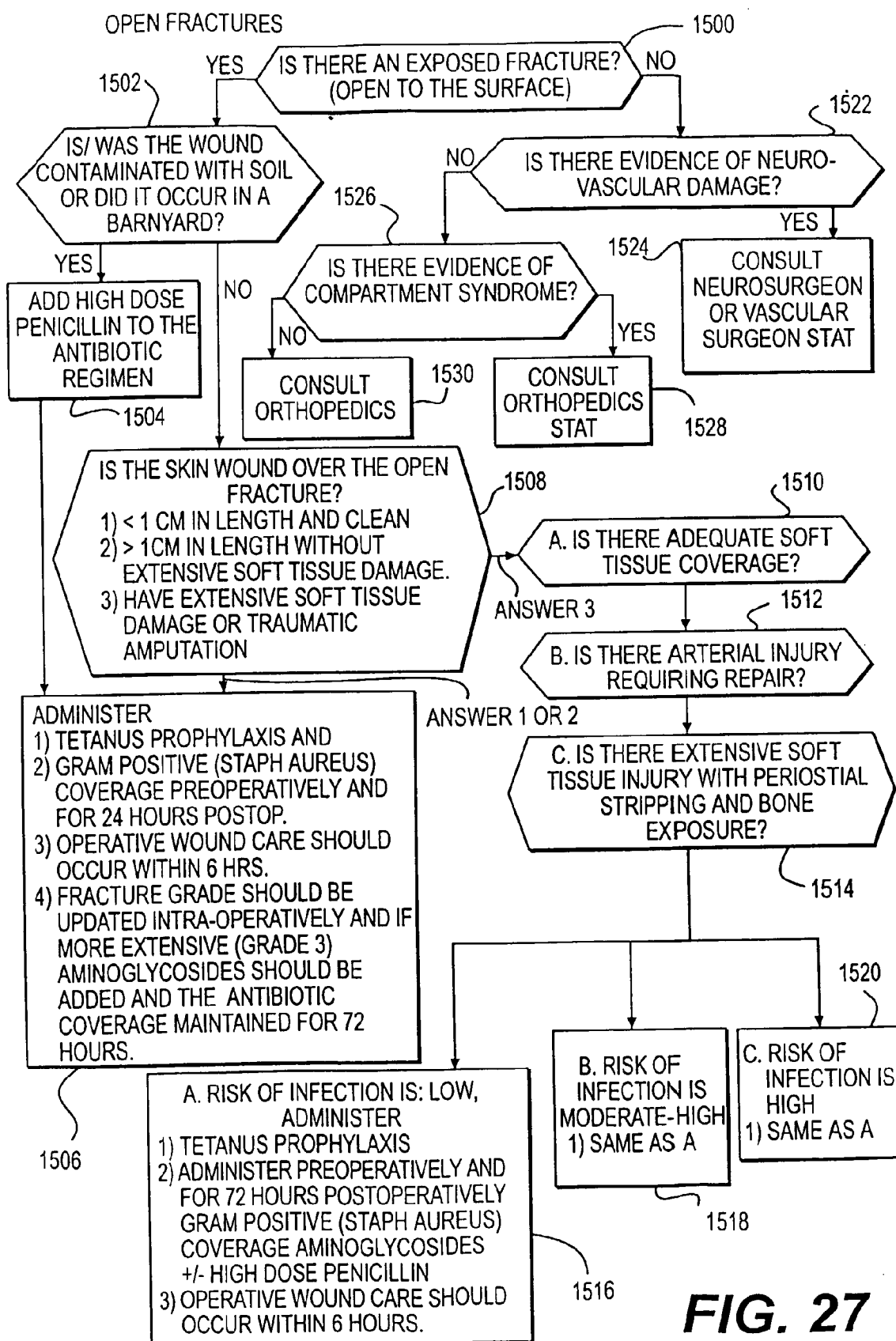
**FIG. 25**

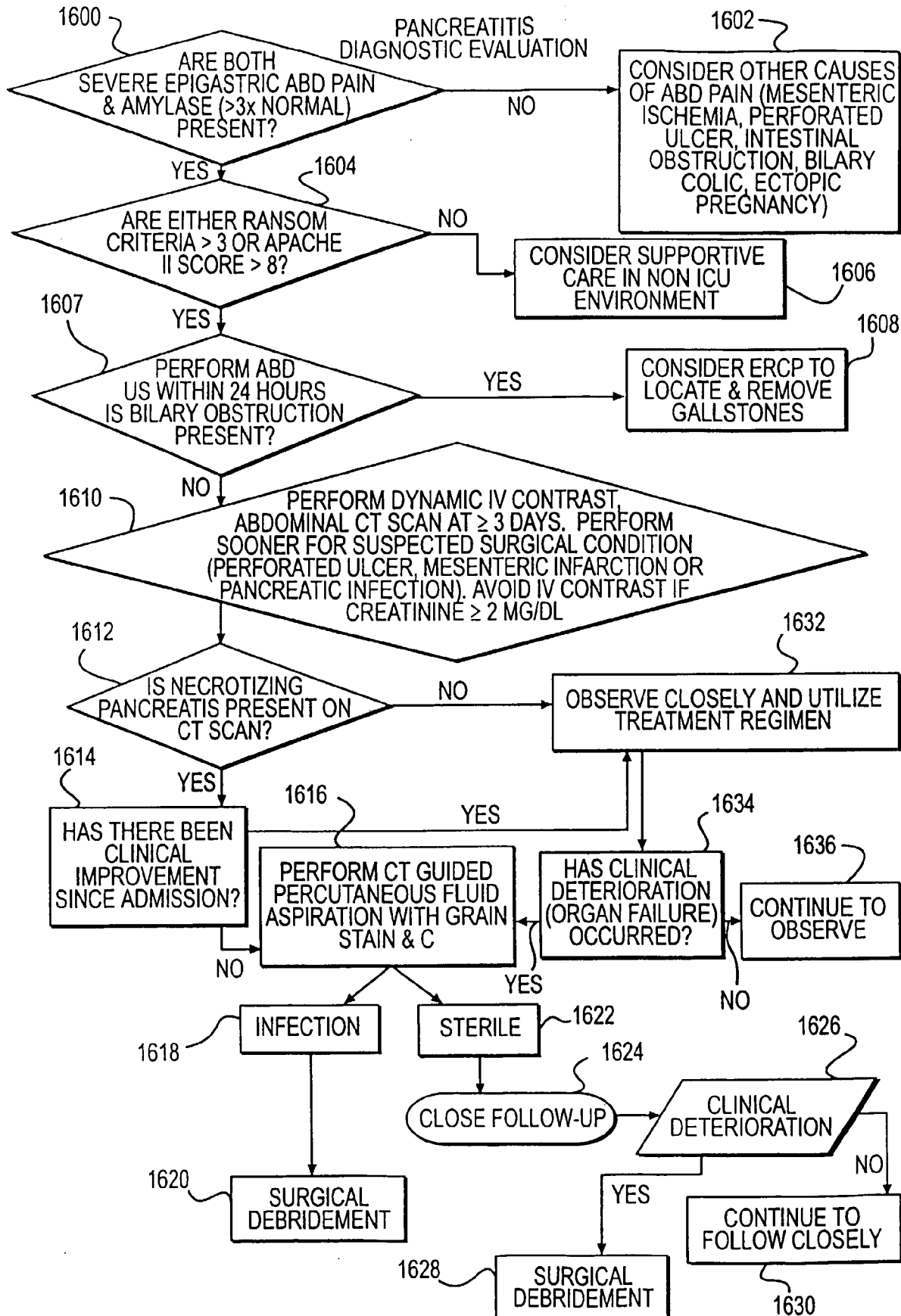
OLIGURIA (PAGE 2)

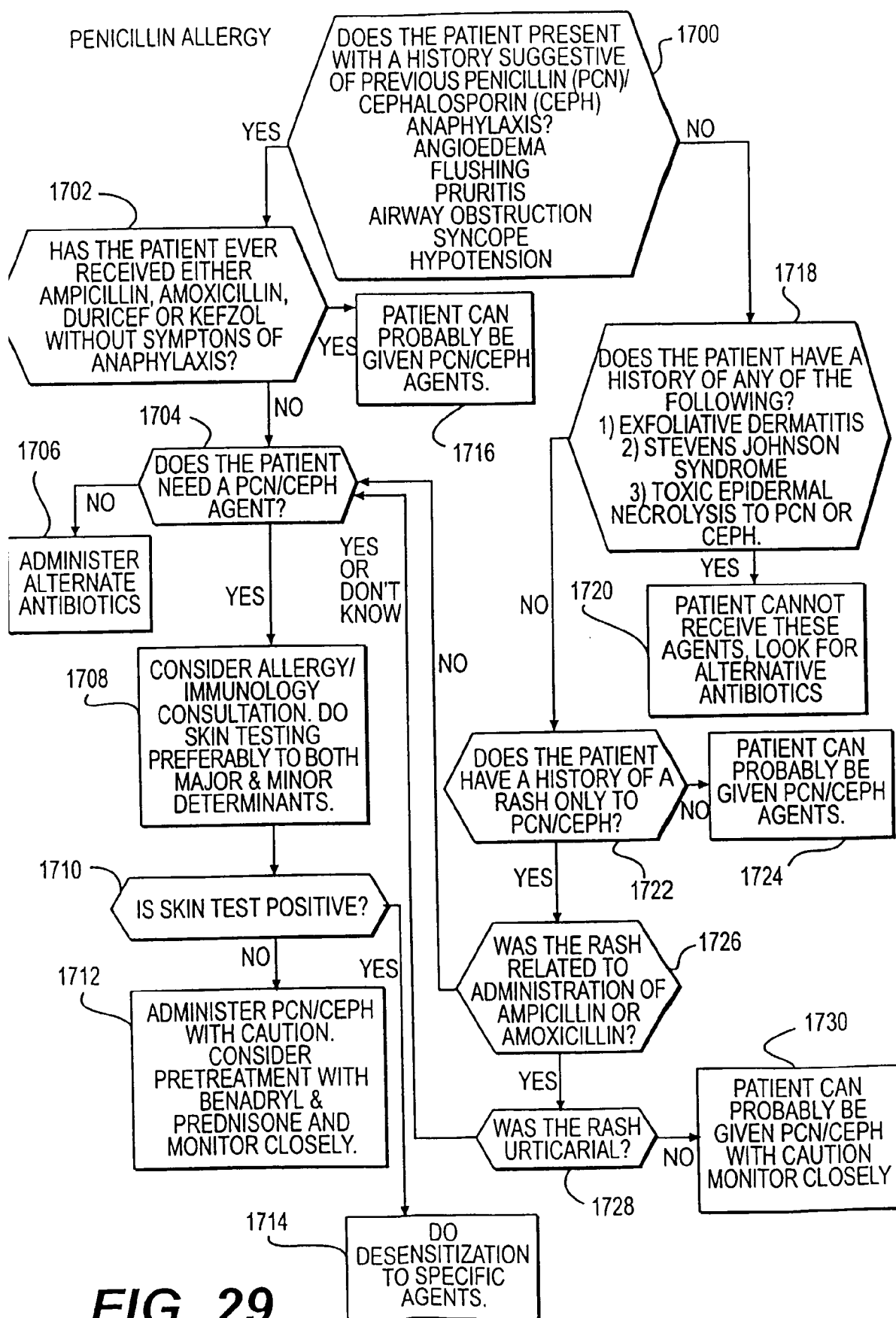
**FIG. 26A**

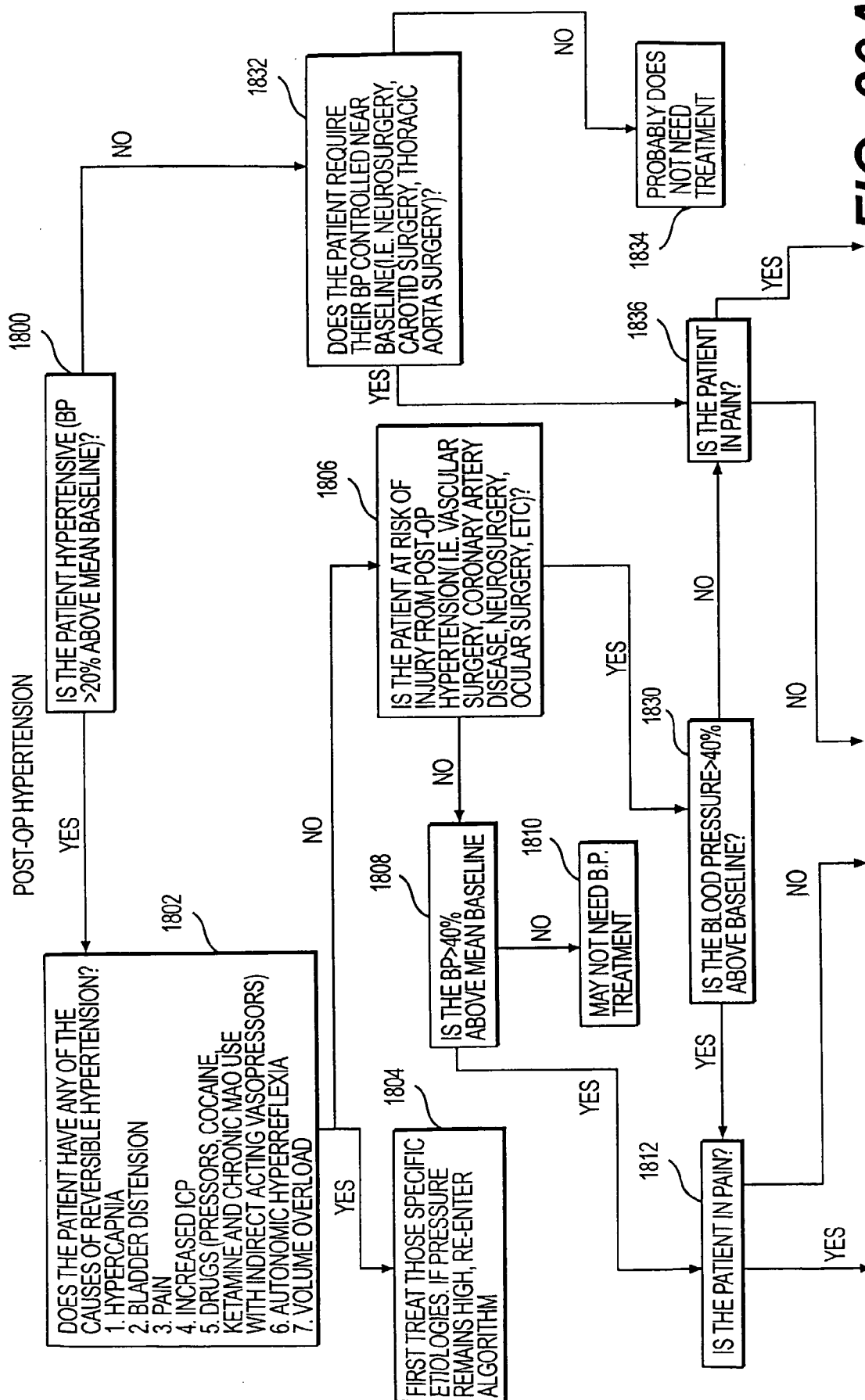


**FIG. 26B**

**FIG. 27**

**FIG. 28**

**FIG. 29**



**FIG. 30A**

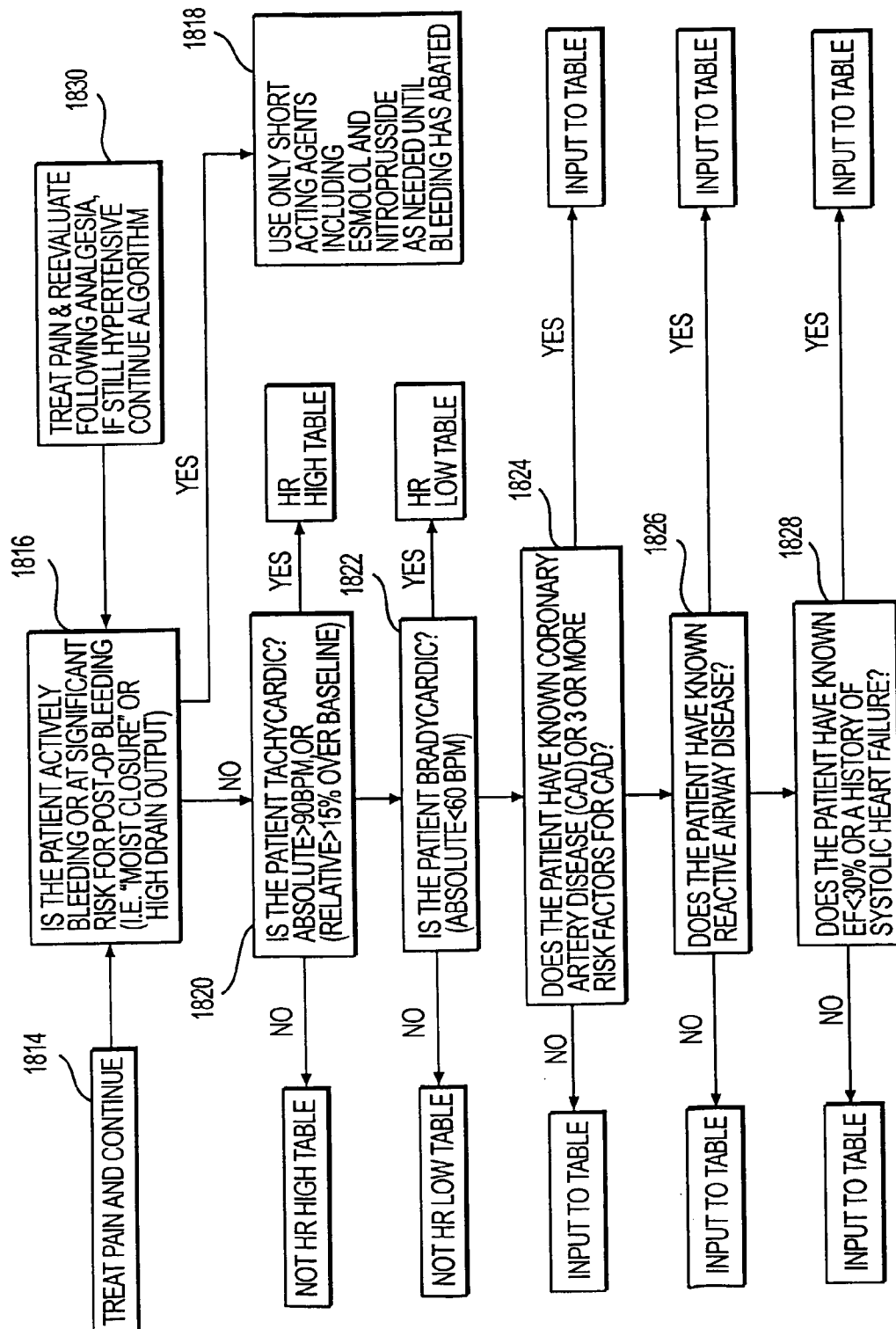
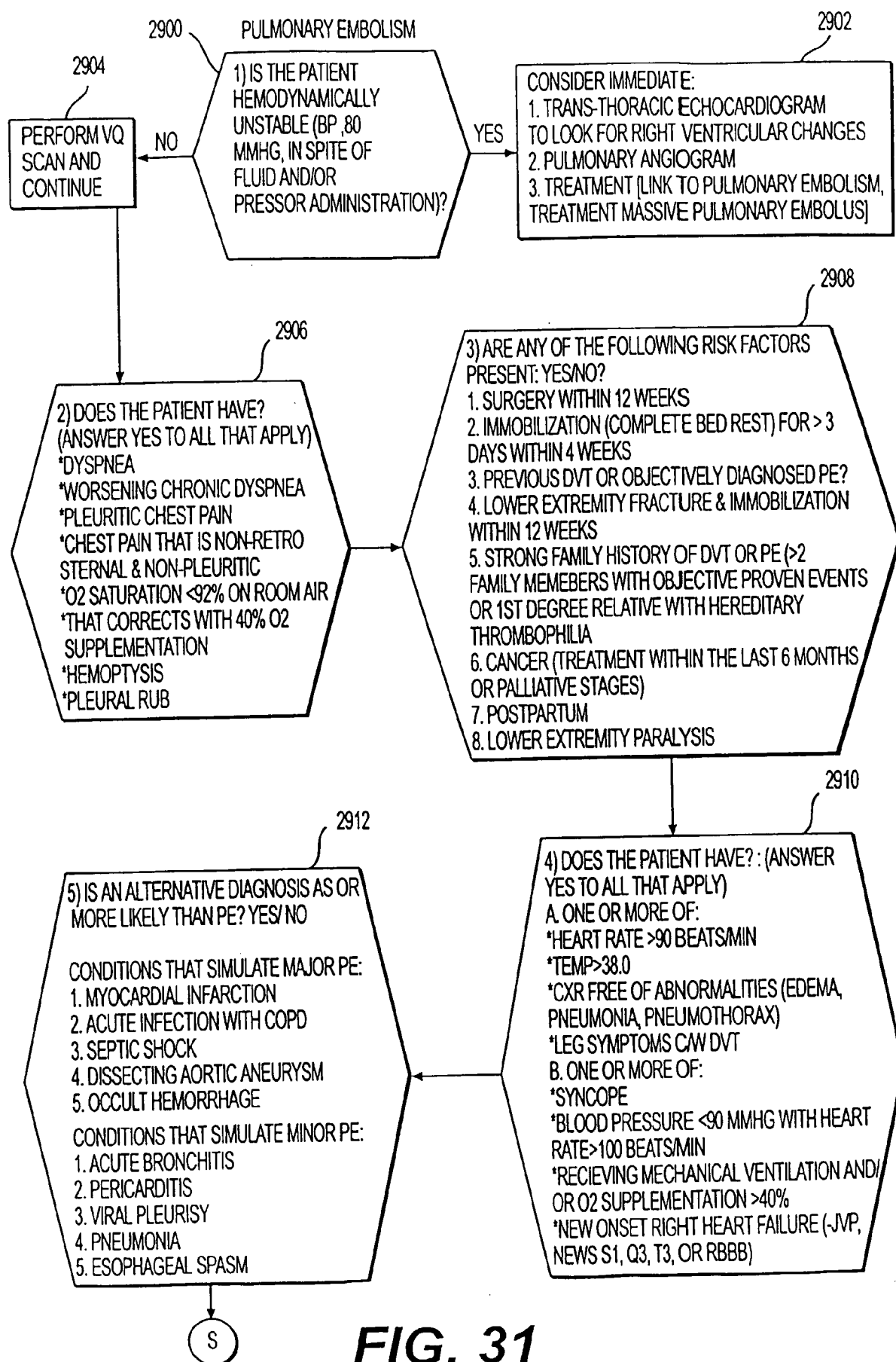
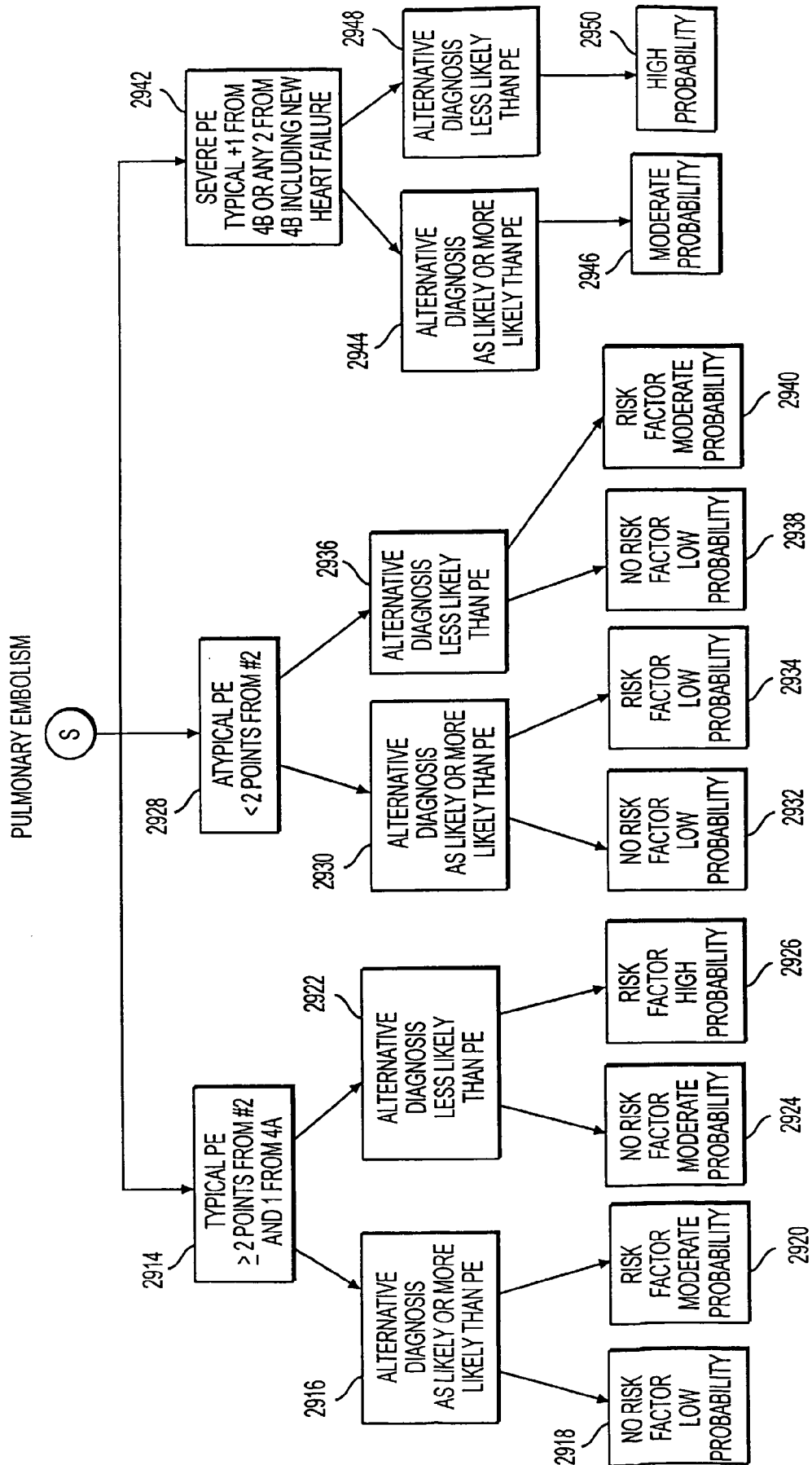


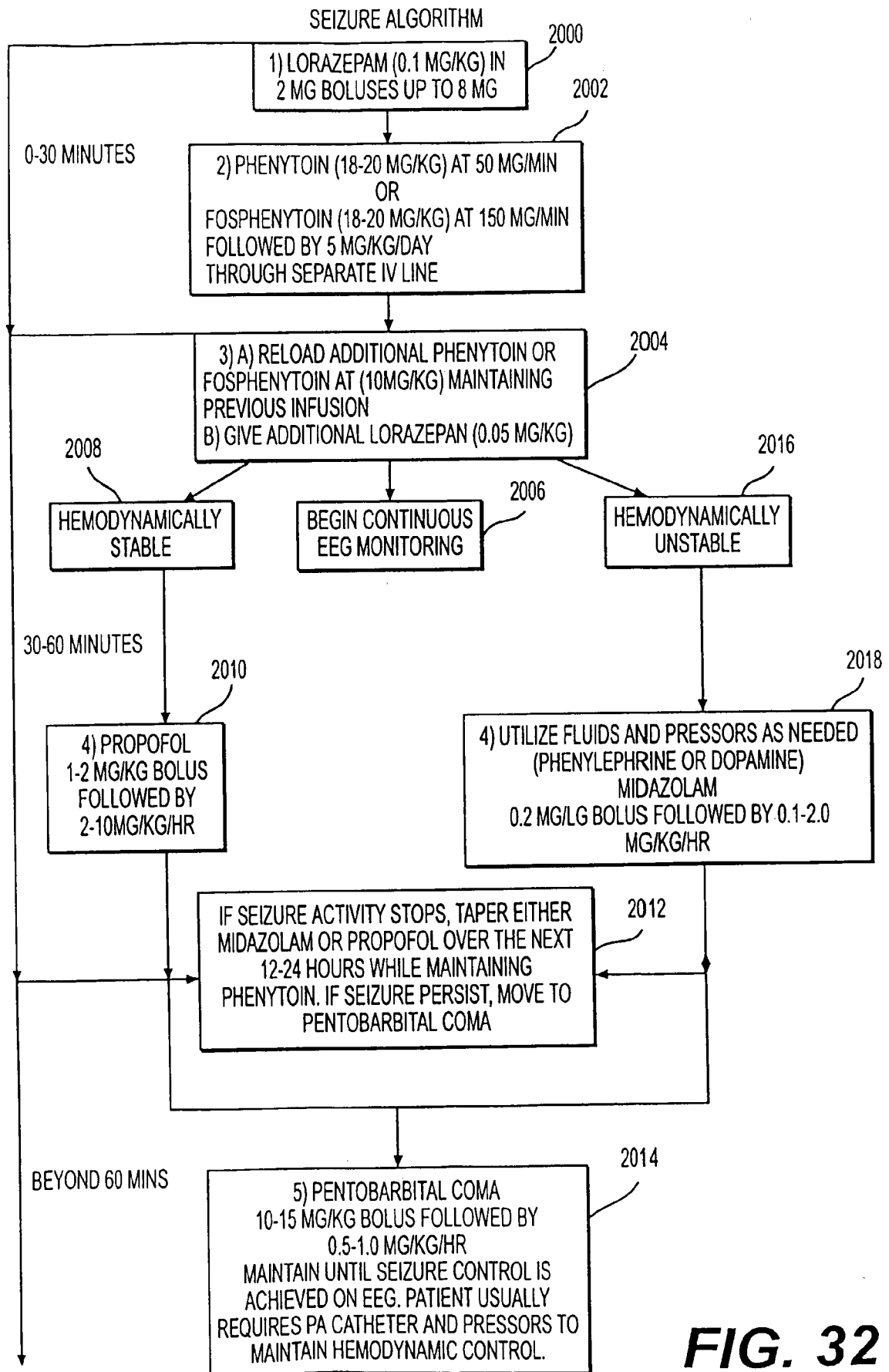
FIG. 30B

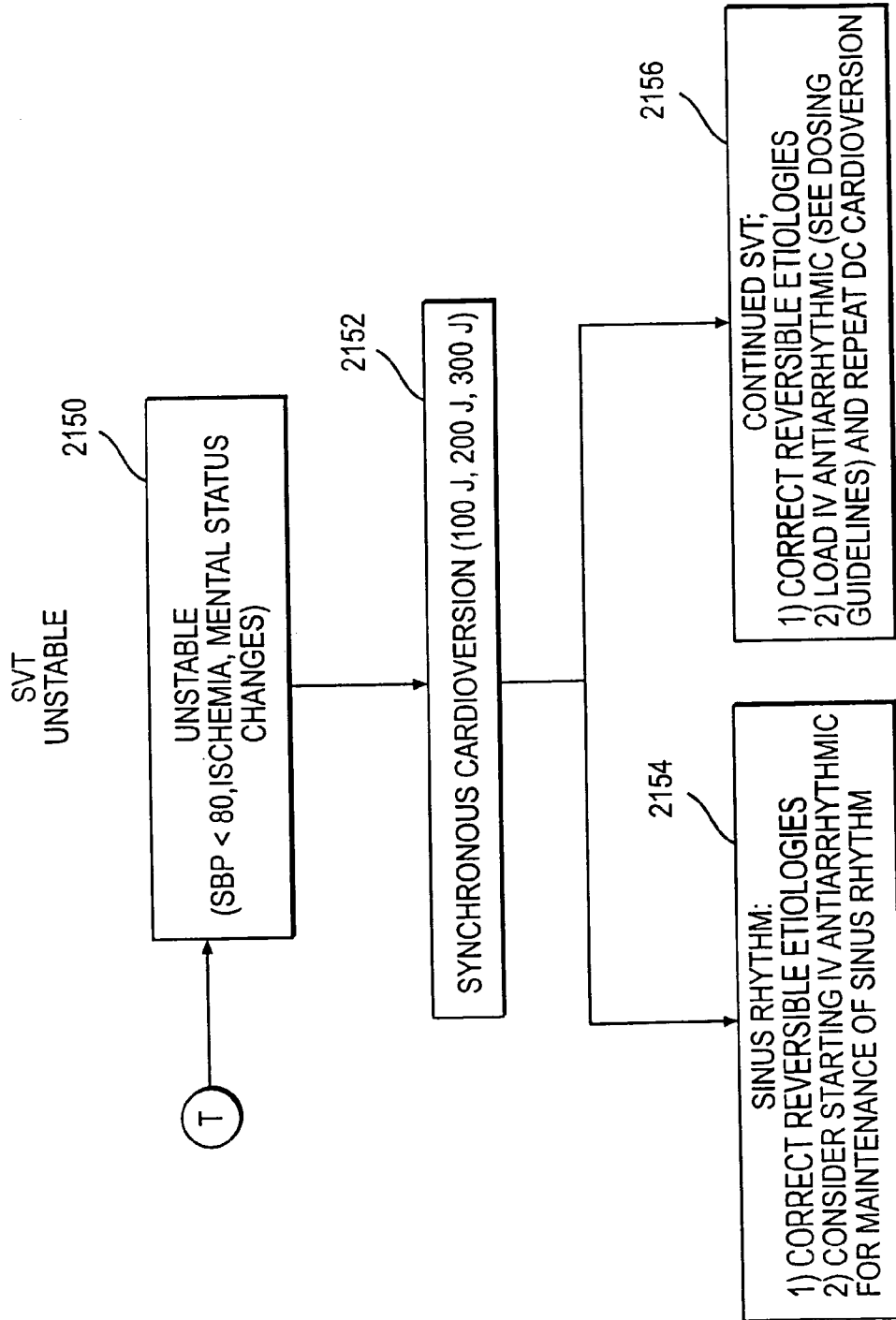
**FIG. 31**



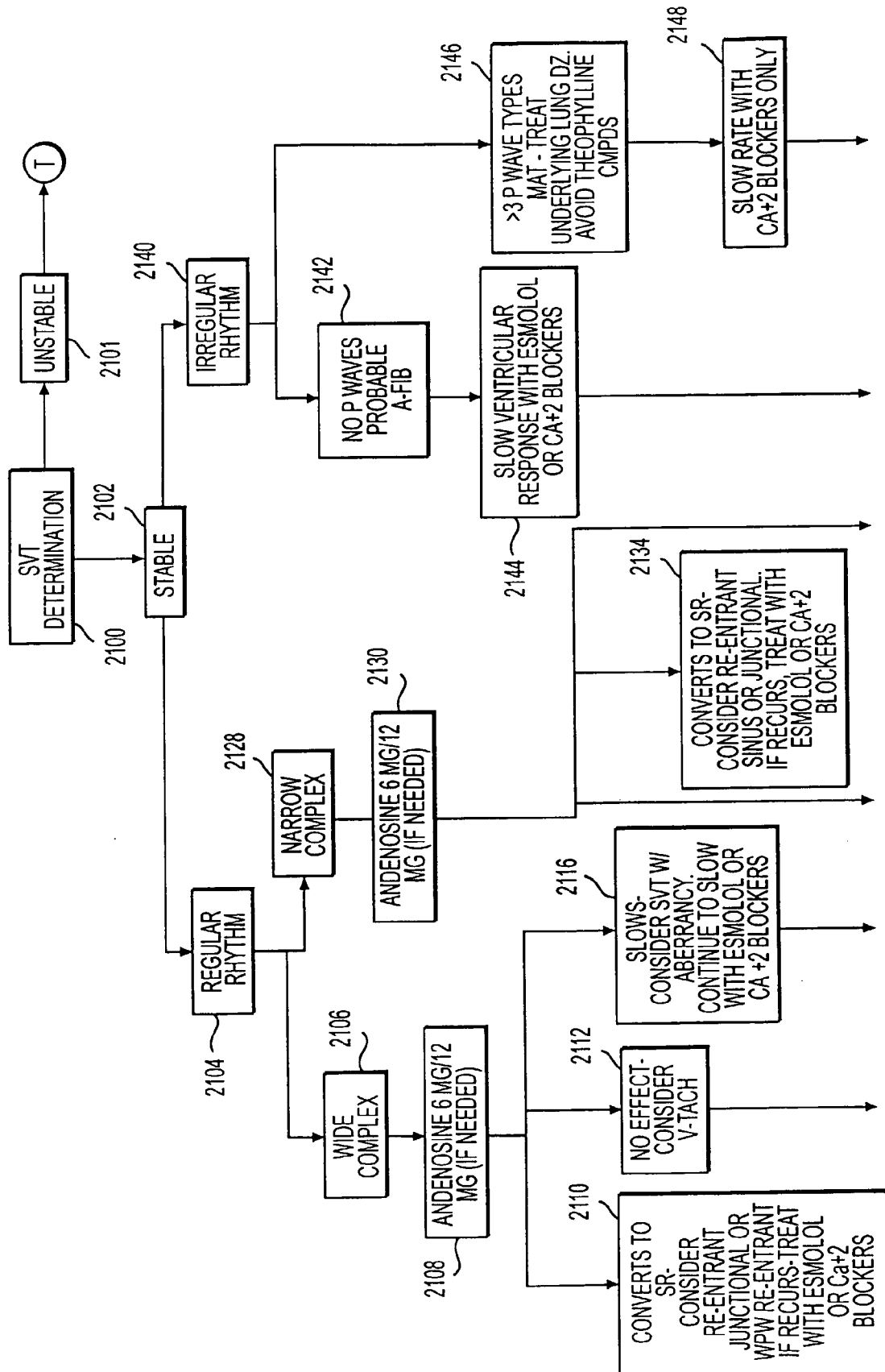
**FIG. 31A**







**FIG. 33A**

**FIG. 33B**

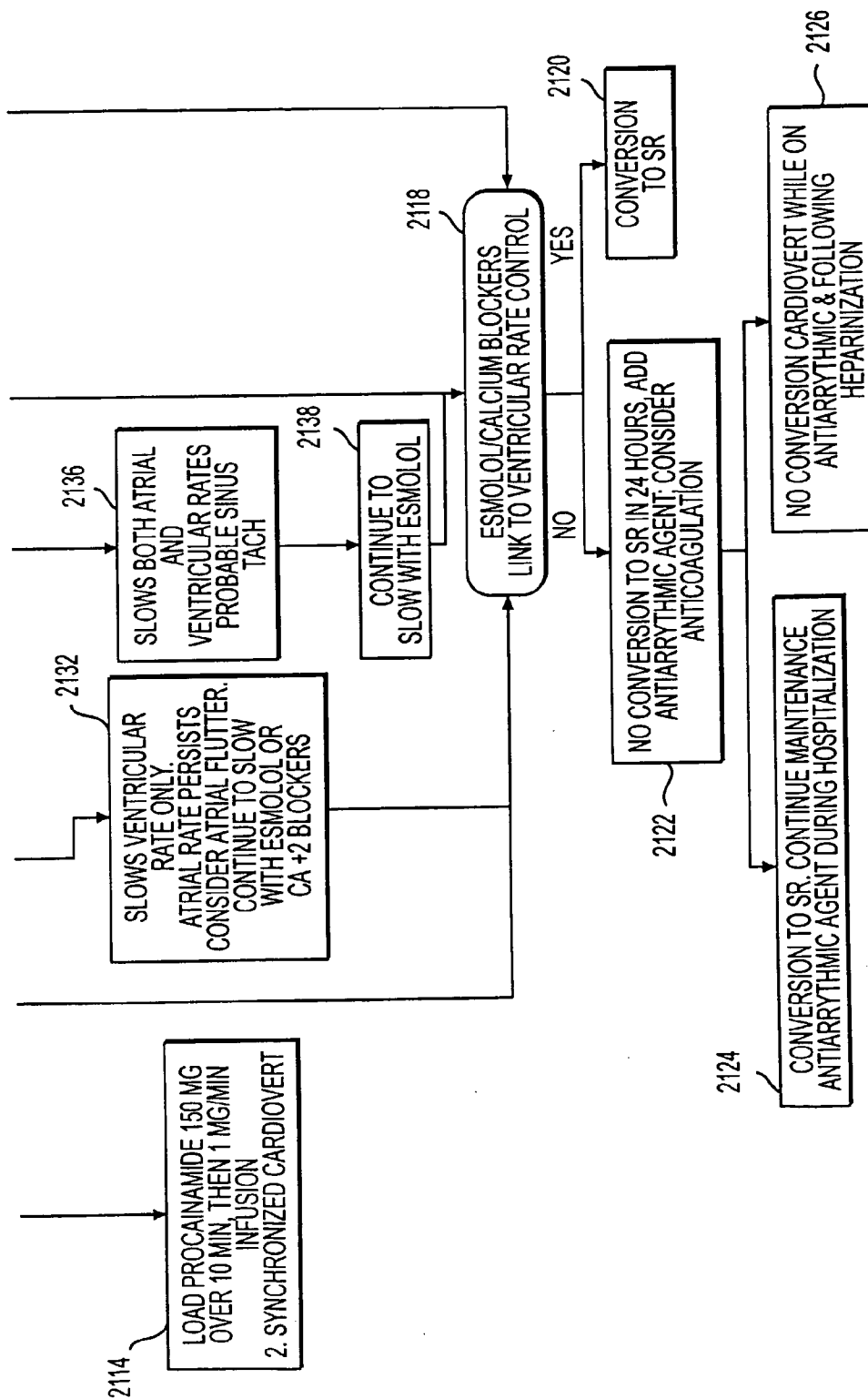
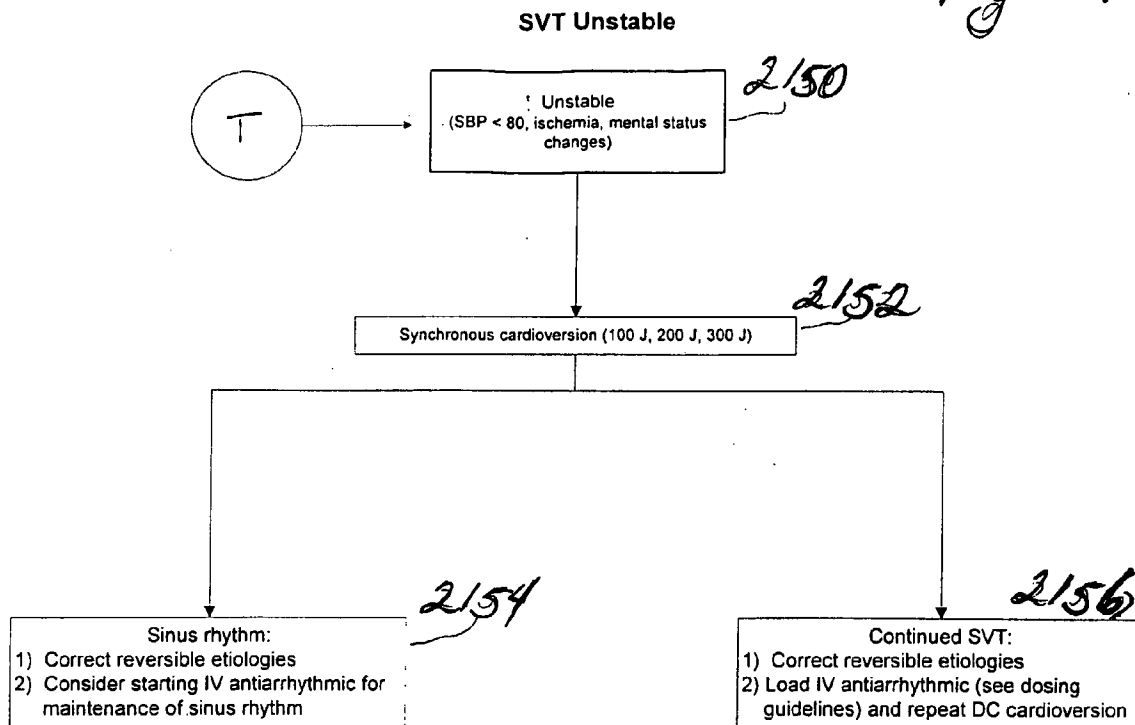
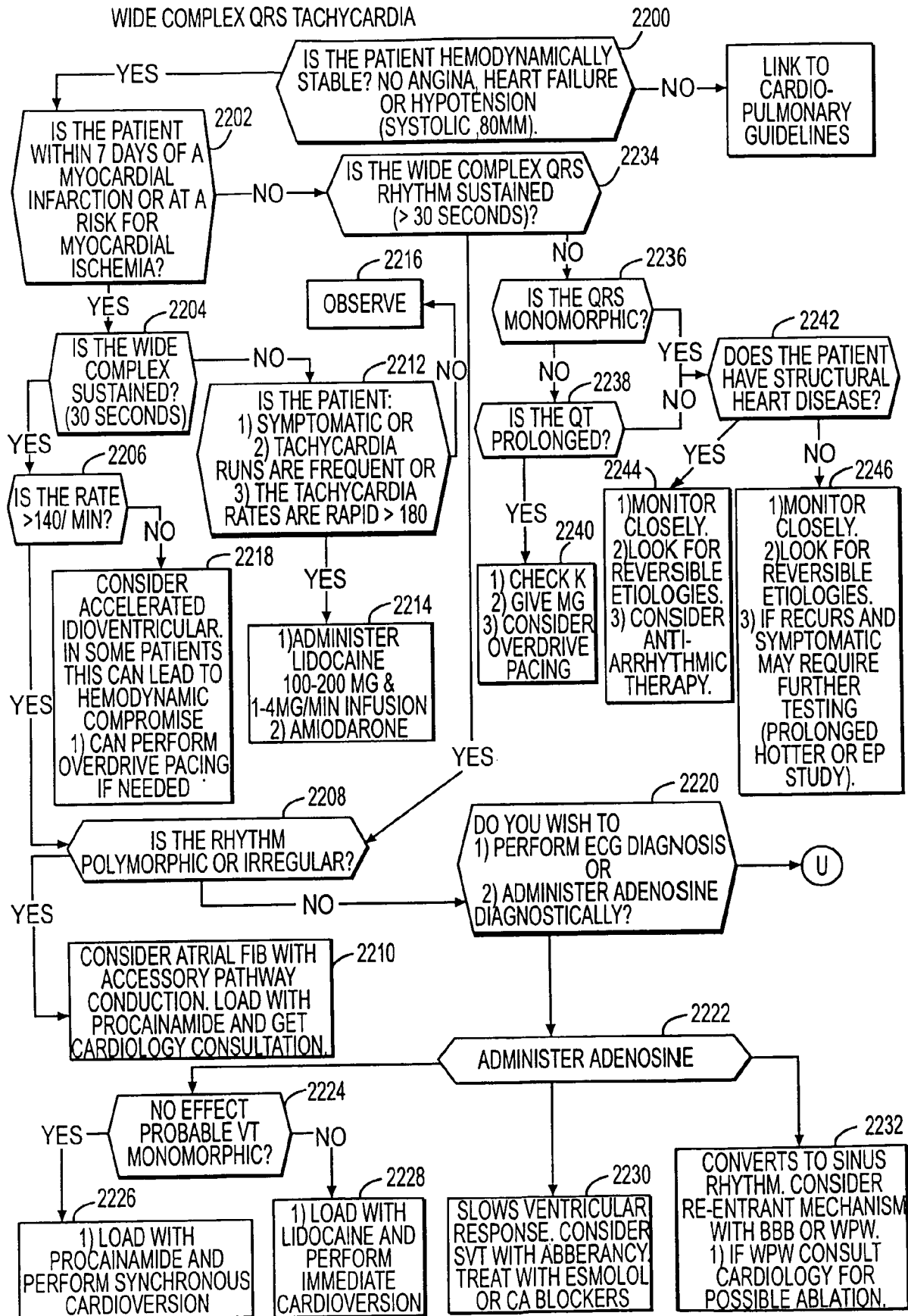


FIG. 33C

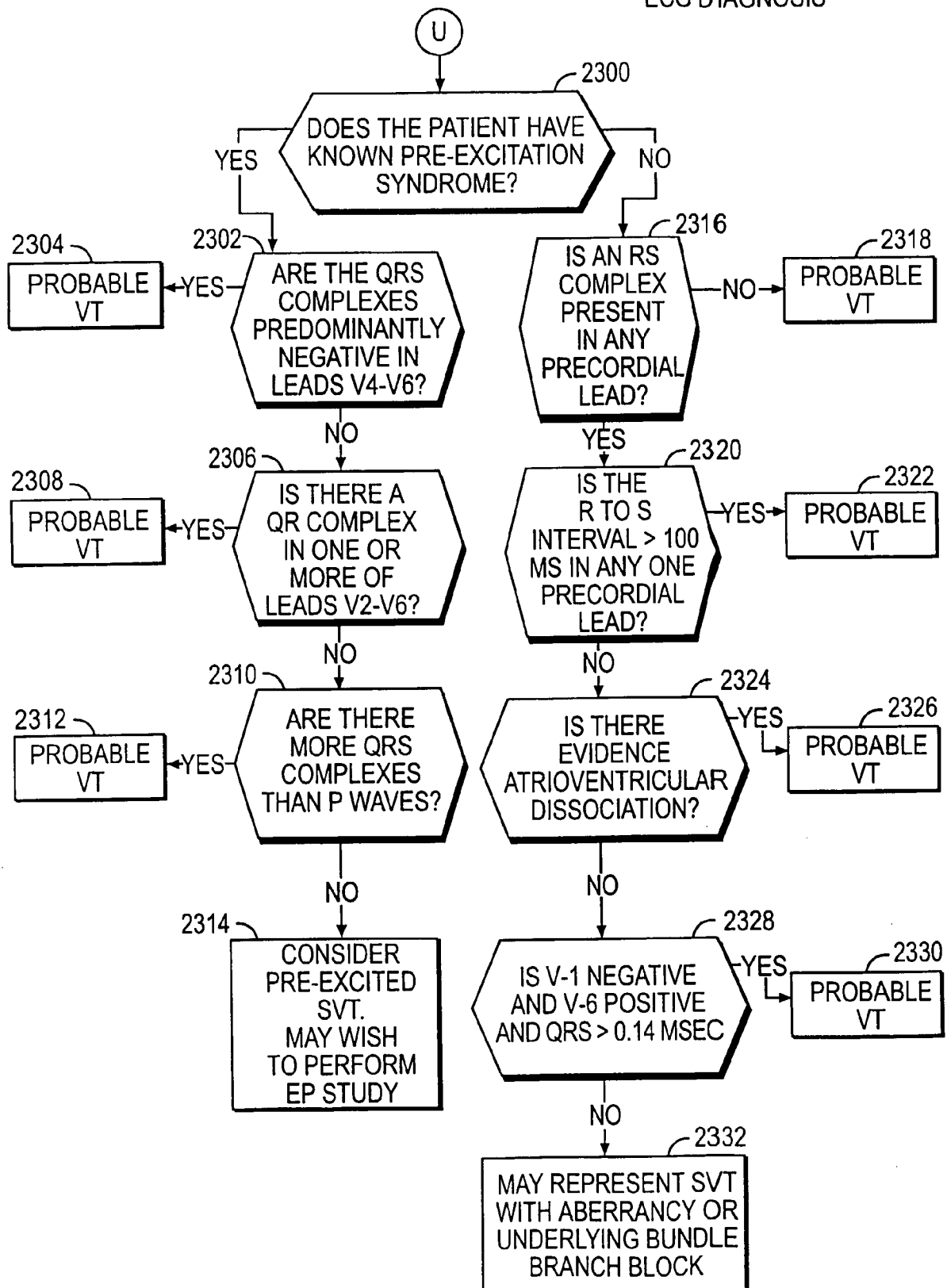
Fig. 33A



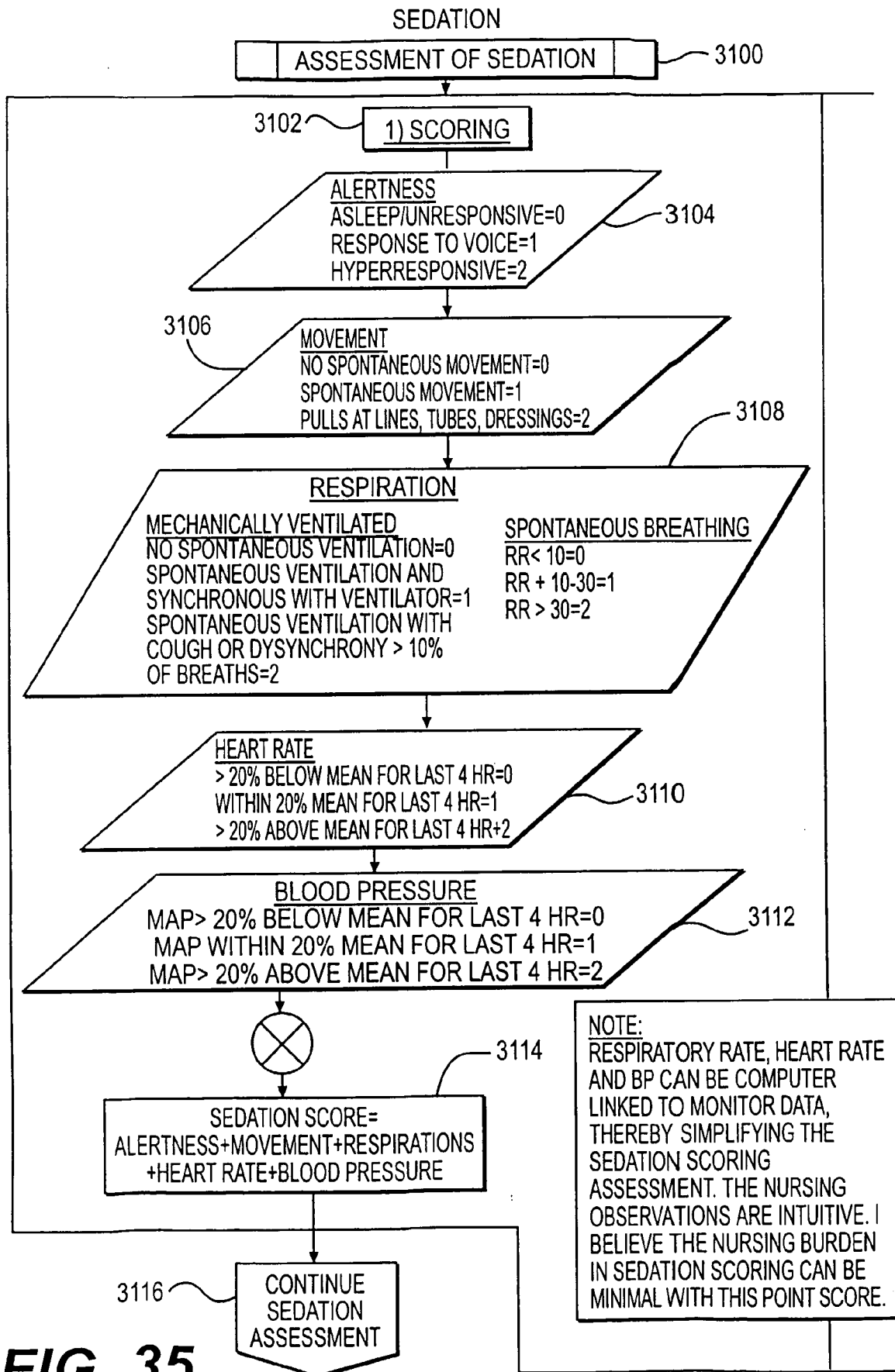


**FIG. 34**

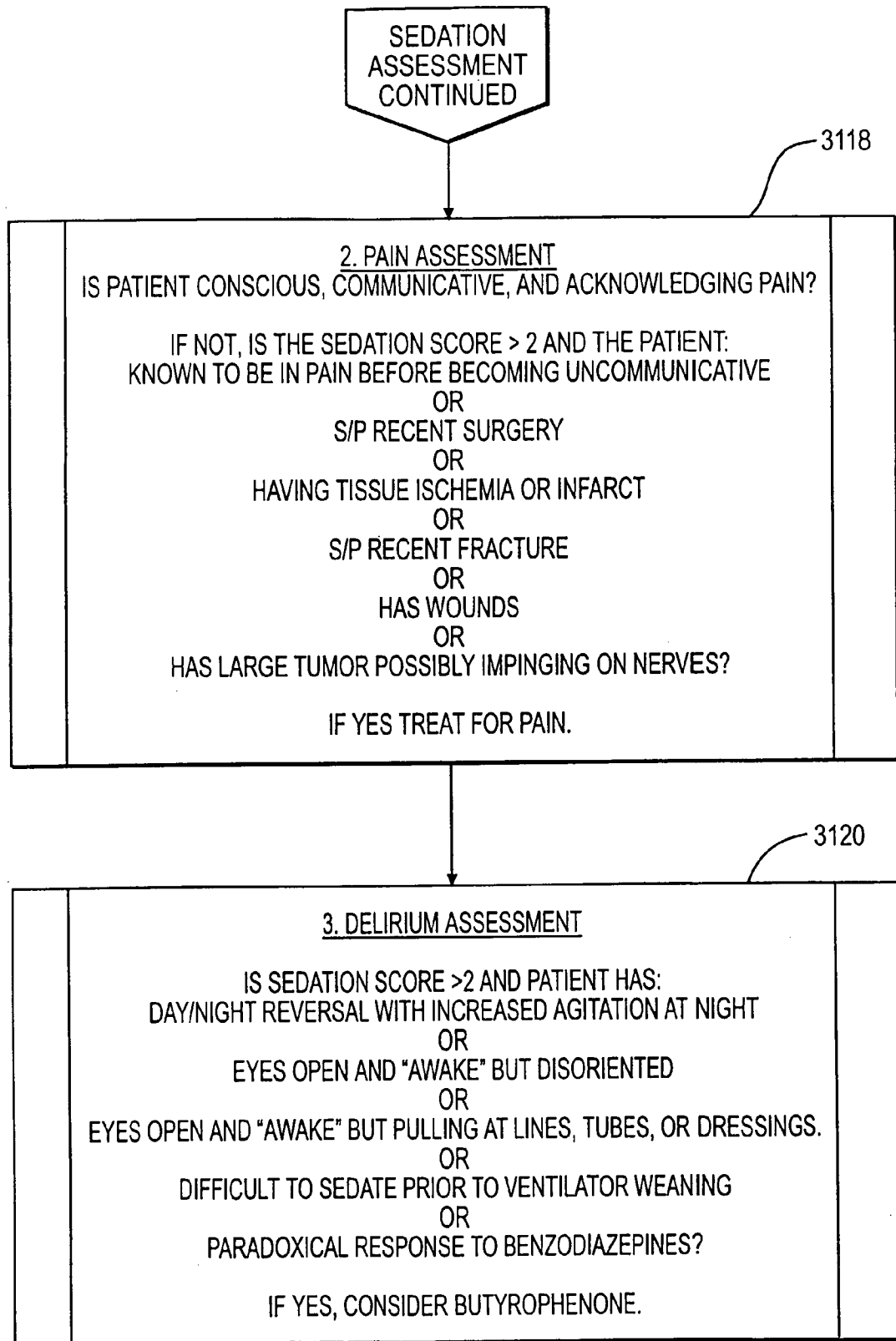
WIDE COMPLEX QRS TACHYCARDIA  
(PAGE 2)  
ECG DIAGNOSIS

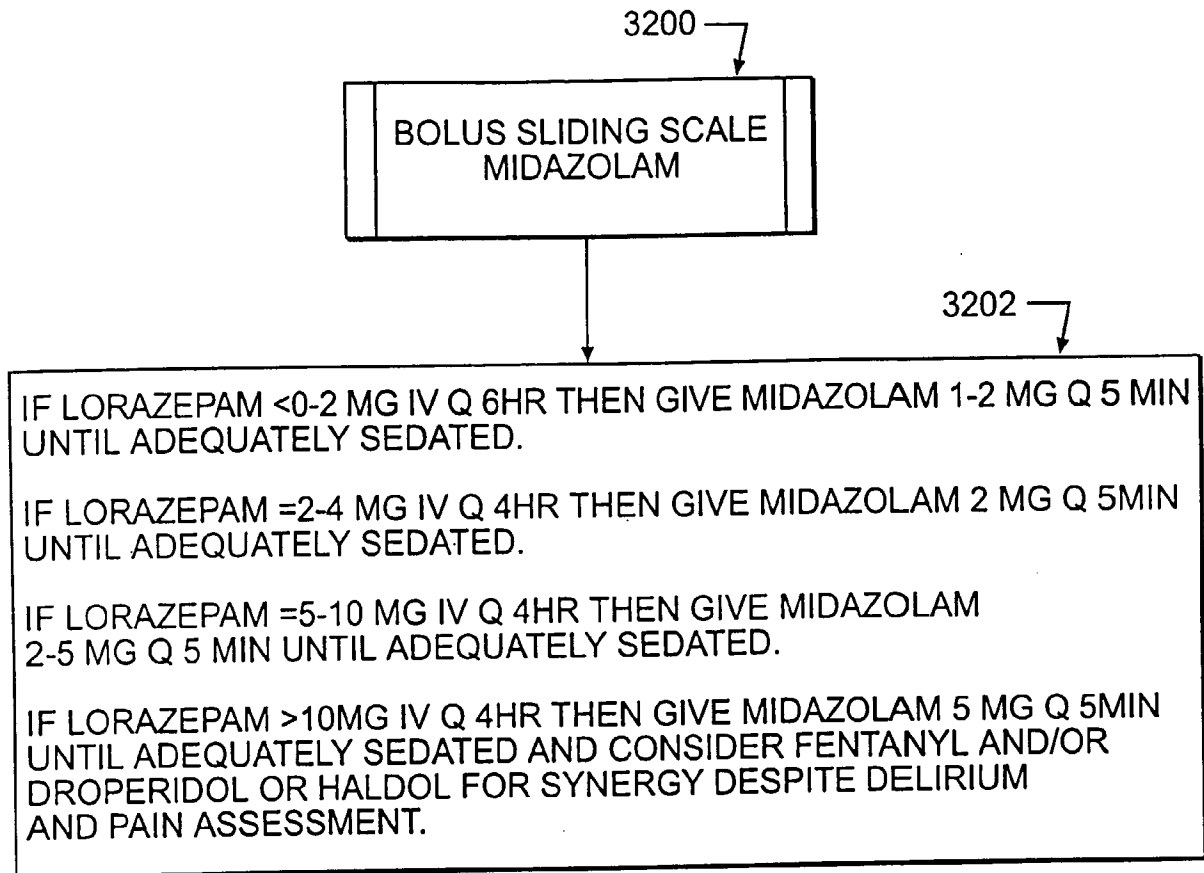


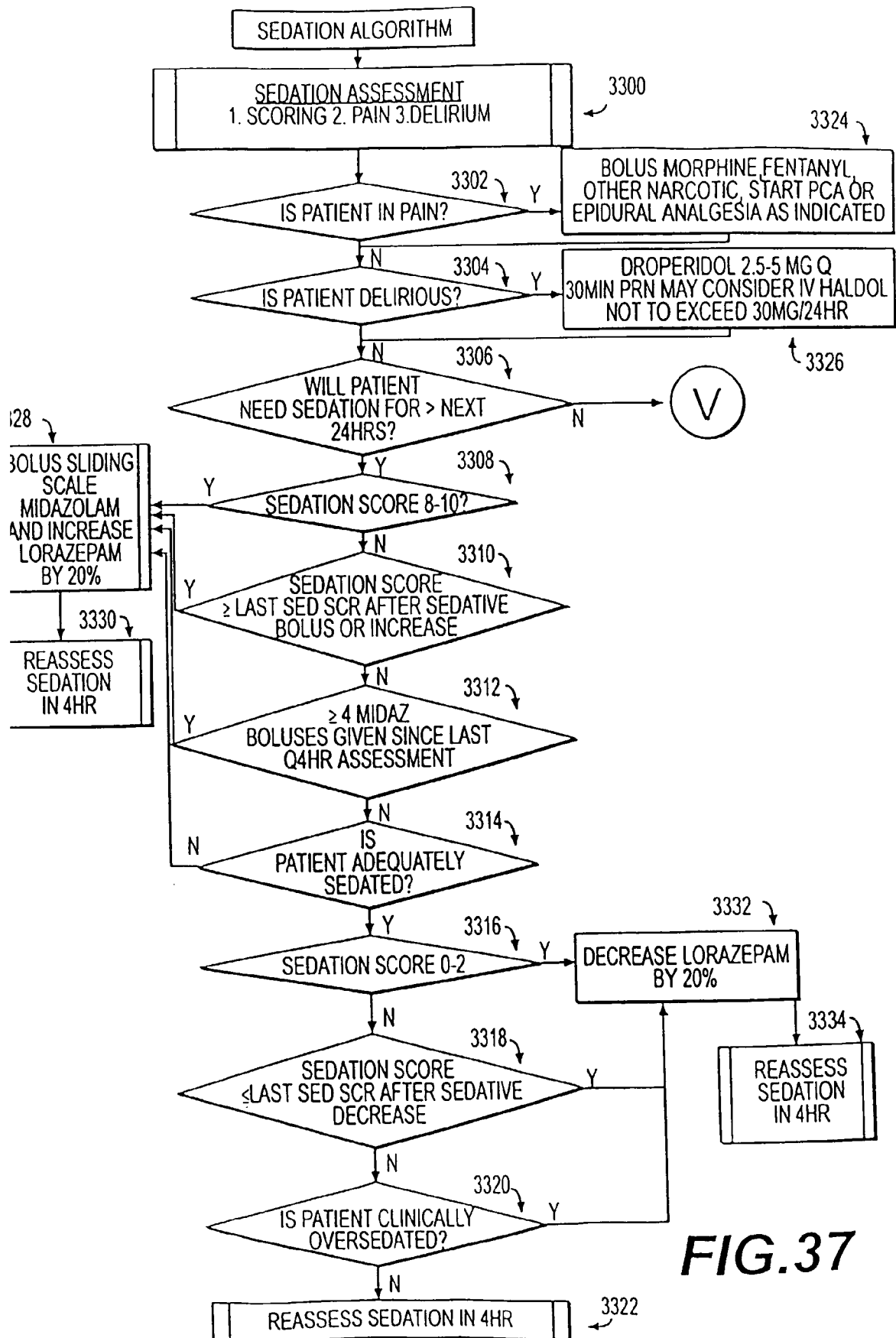
**FIG. 34A**

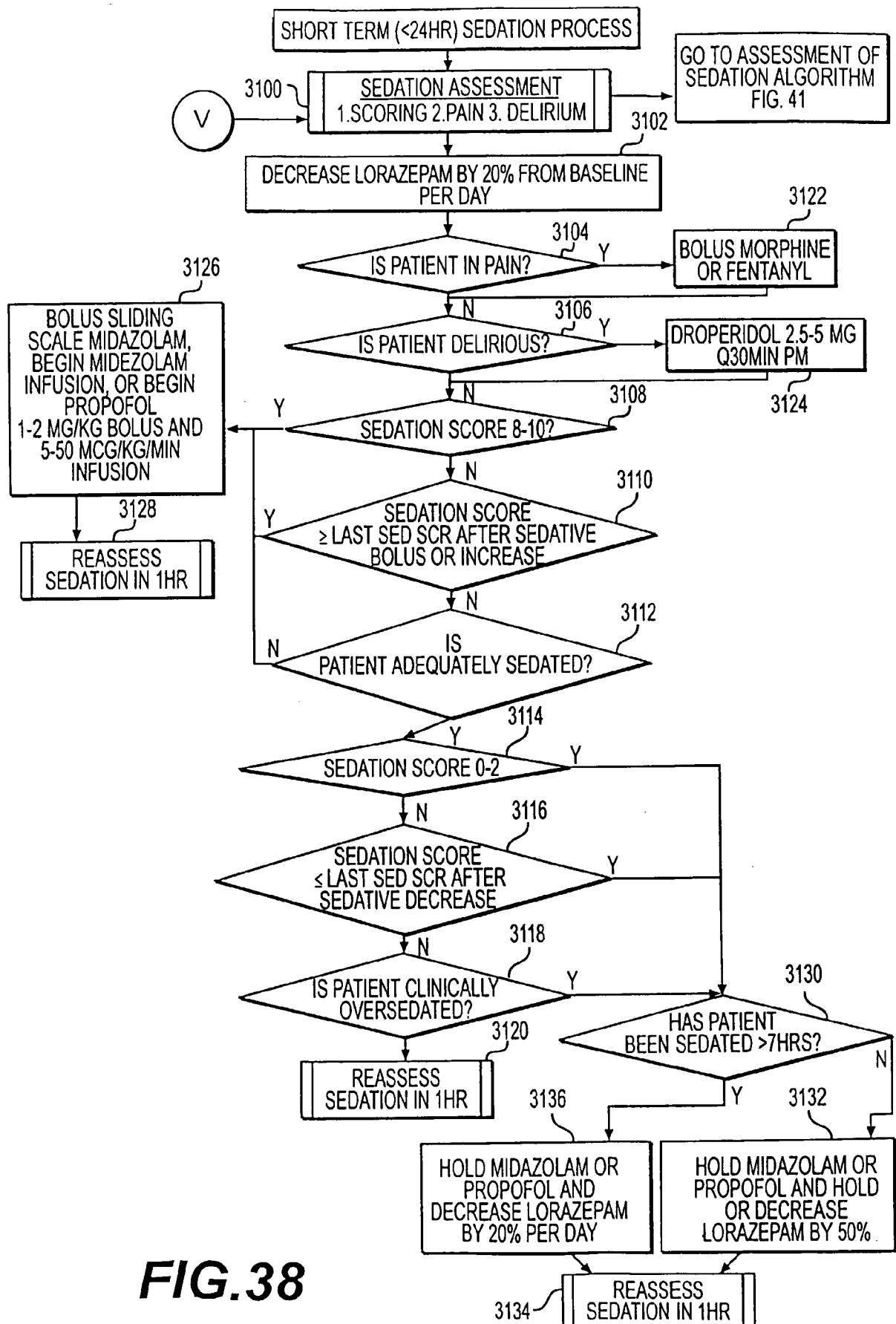
**FIG. 35**

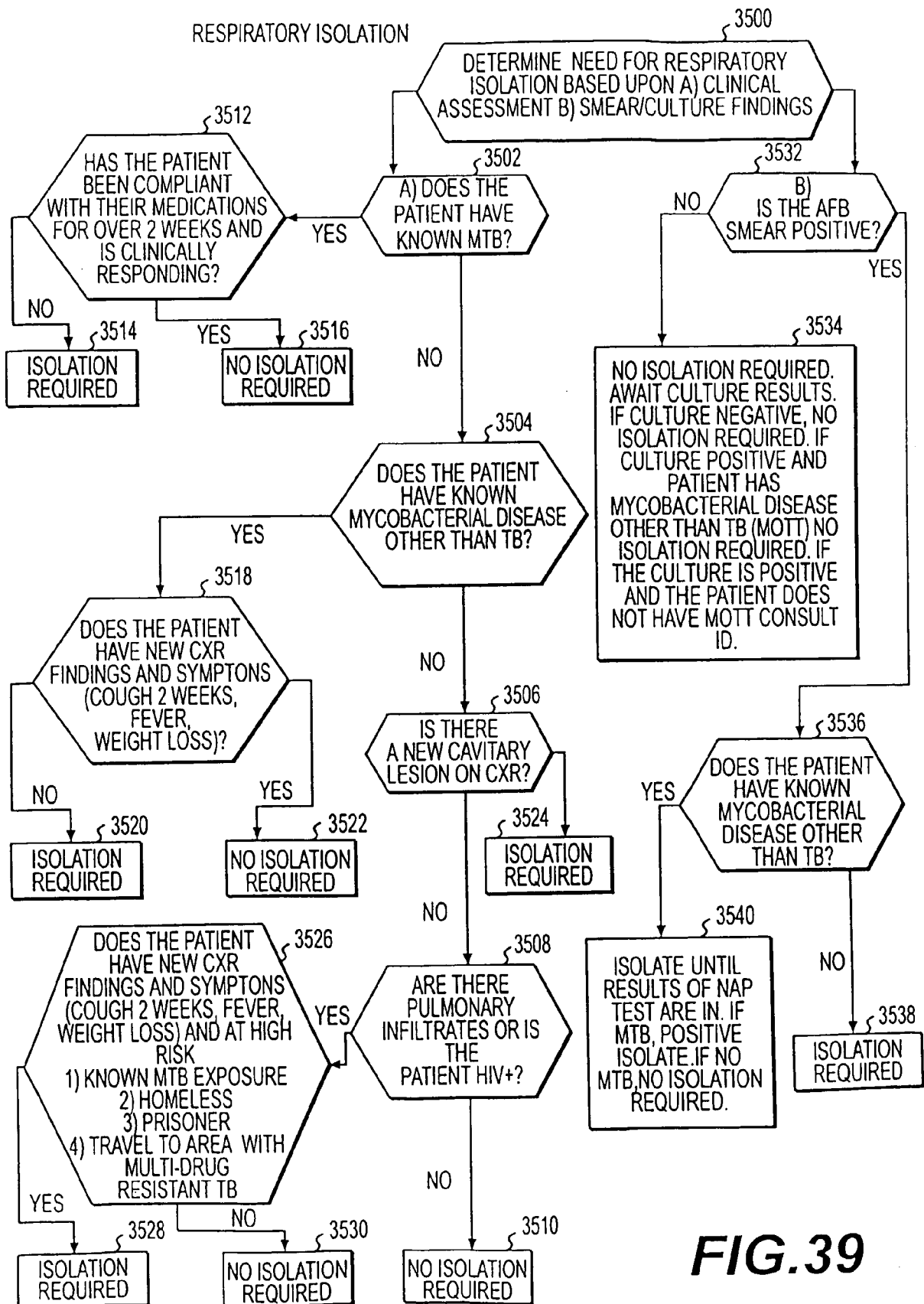


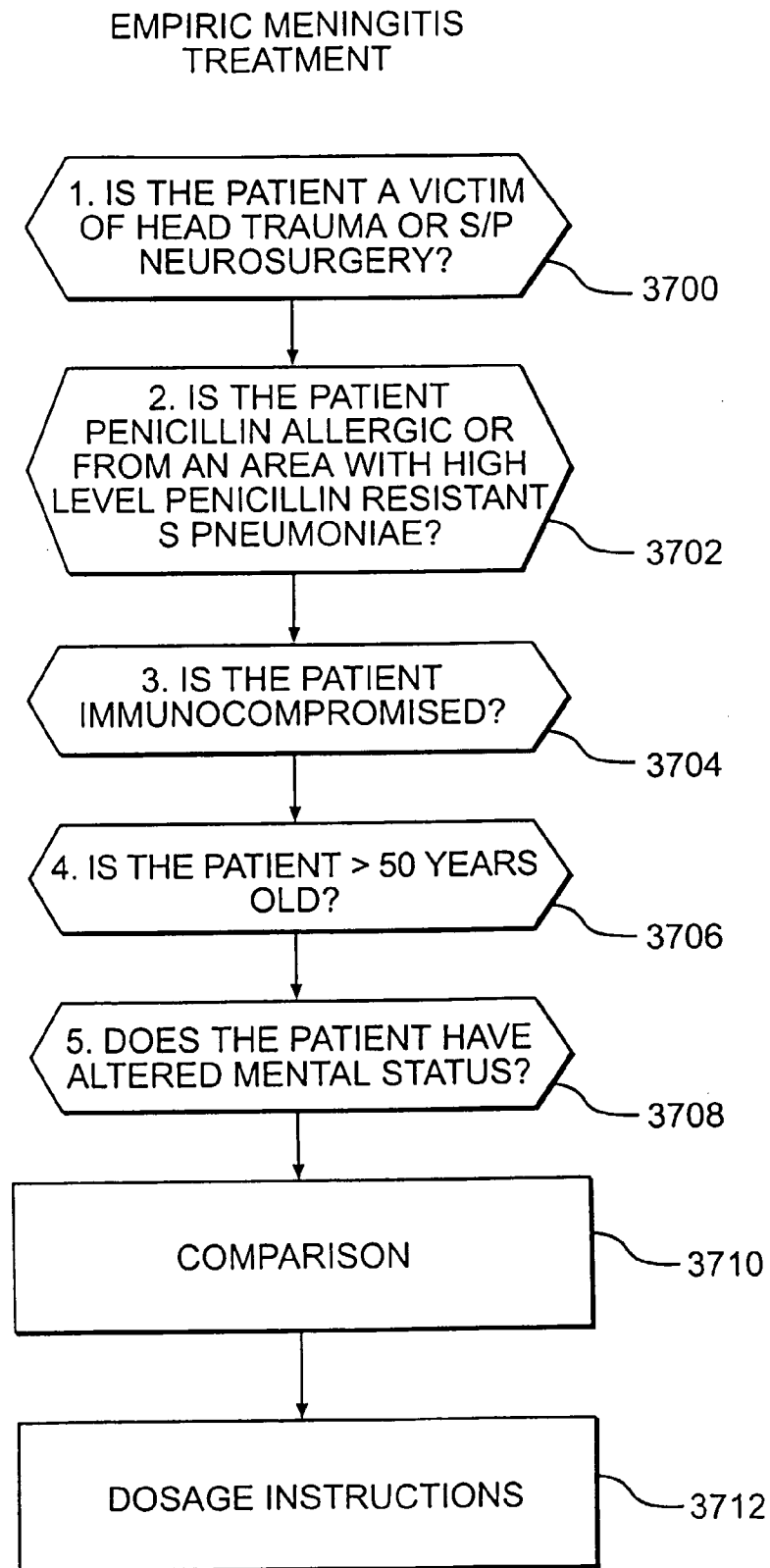
**FIG. 35A**

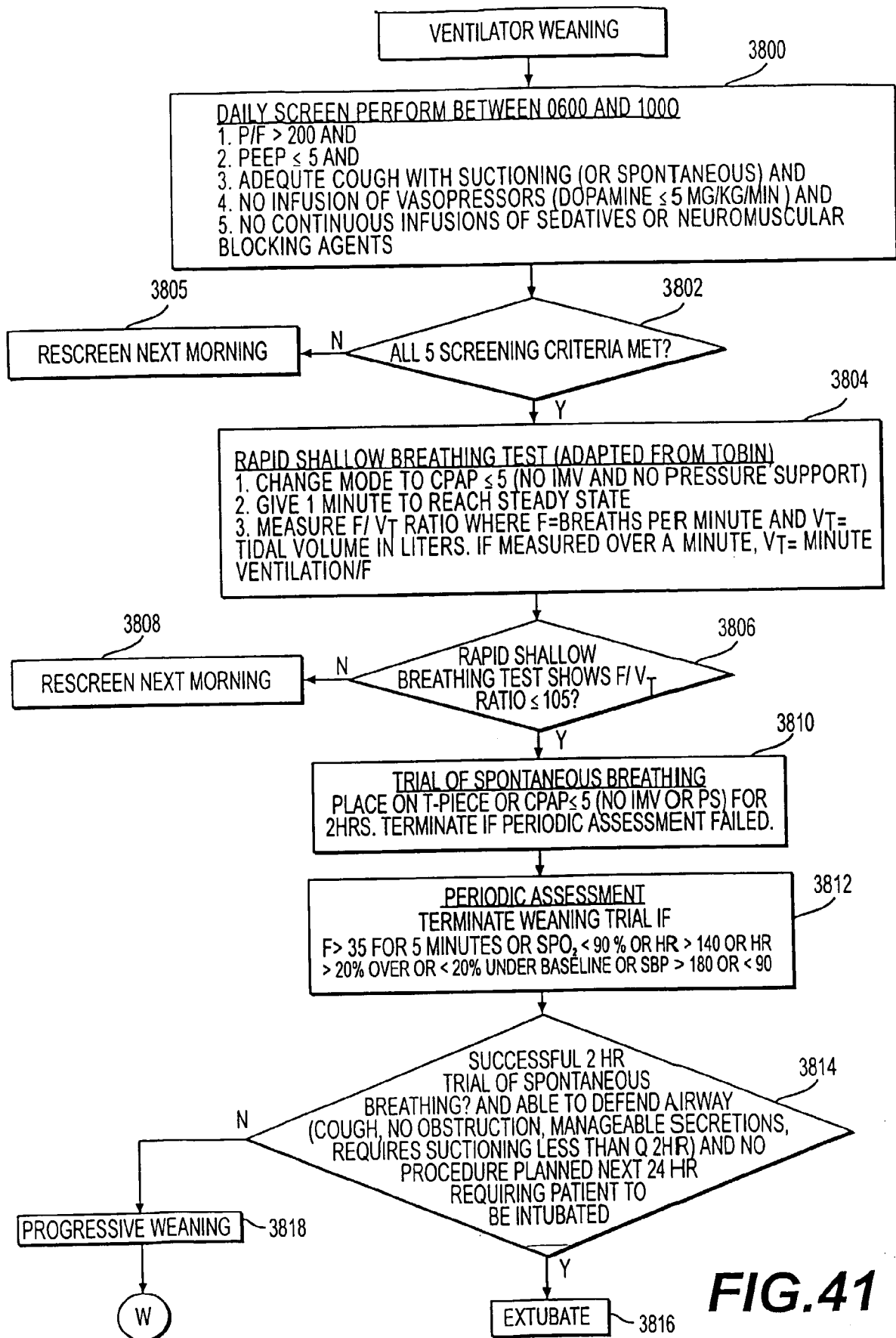
**FIG.36**

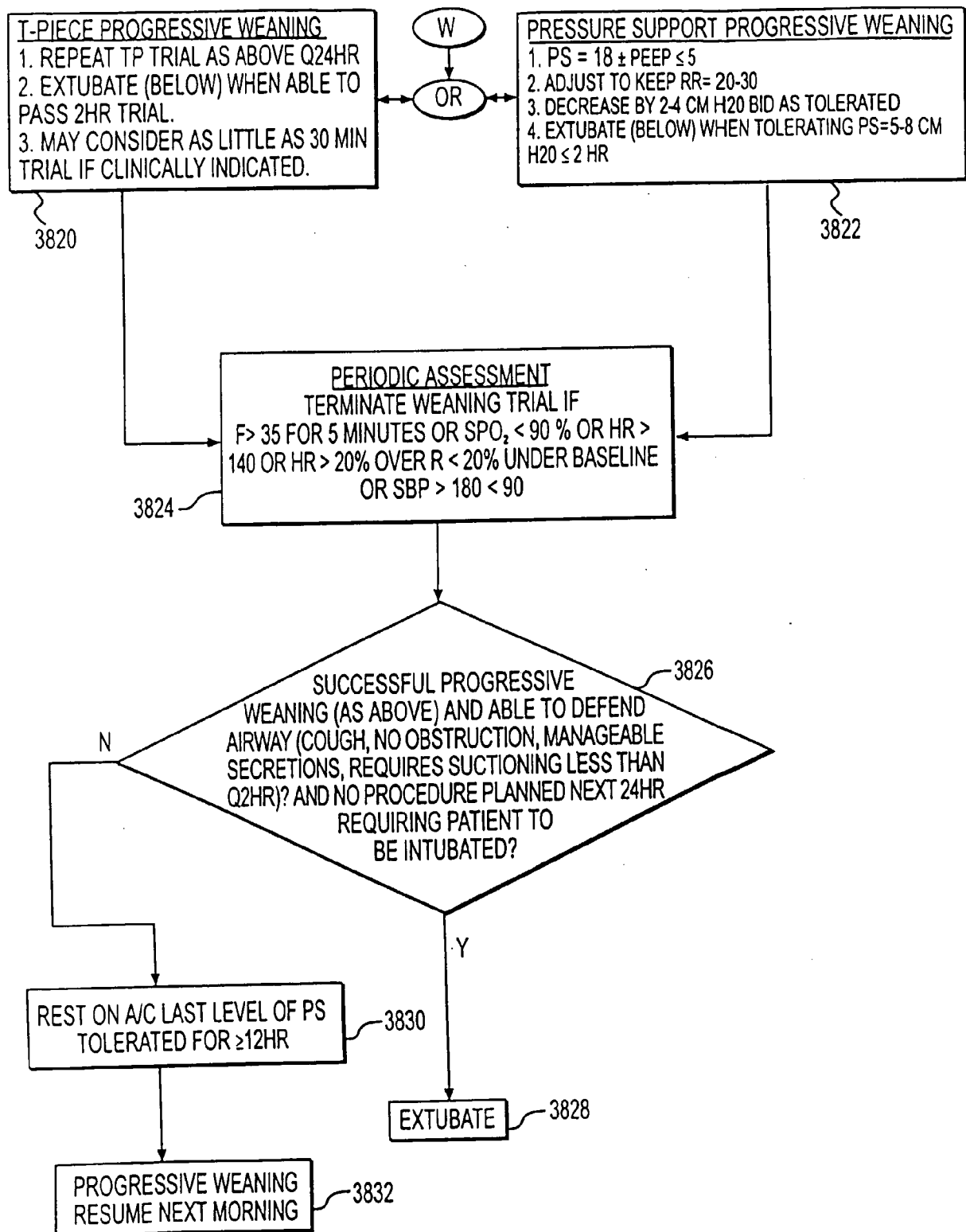


**FIG.38**



**FIG.40**

**FIG. 41**

**FIG. 41A**



## WARFARIN DOSING ALGORITHM

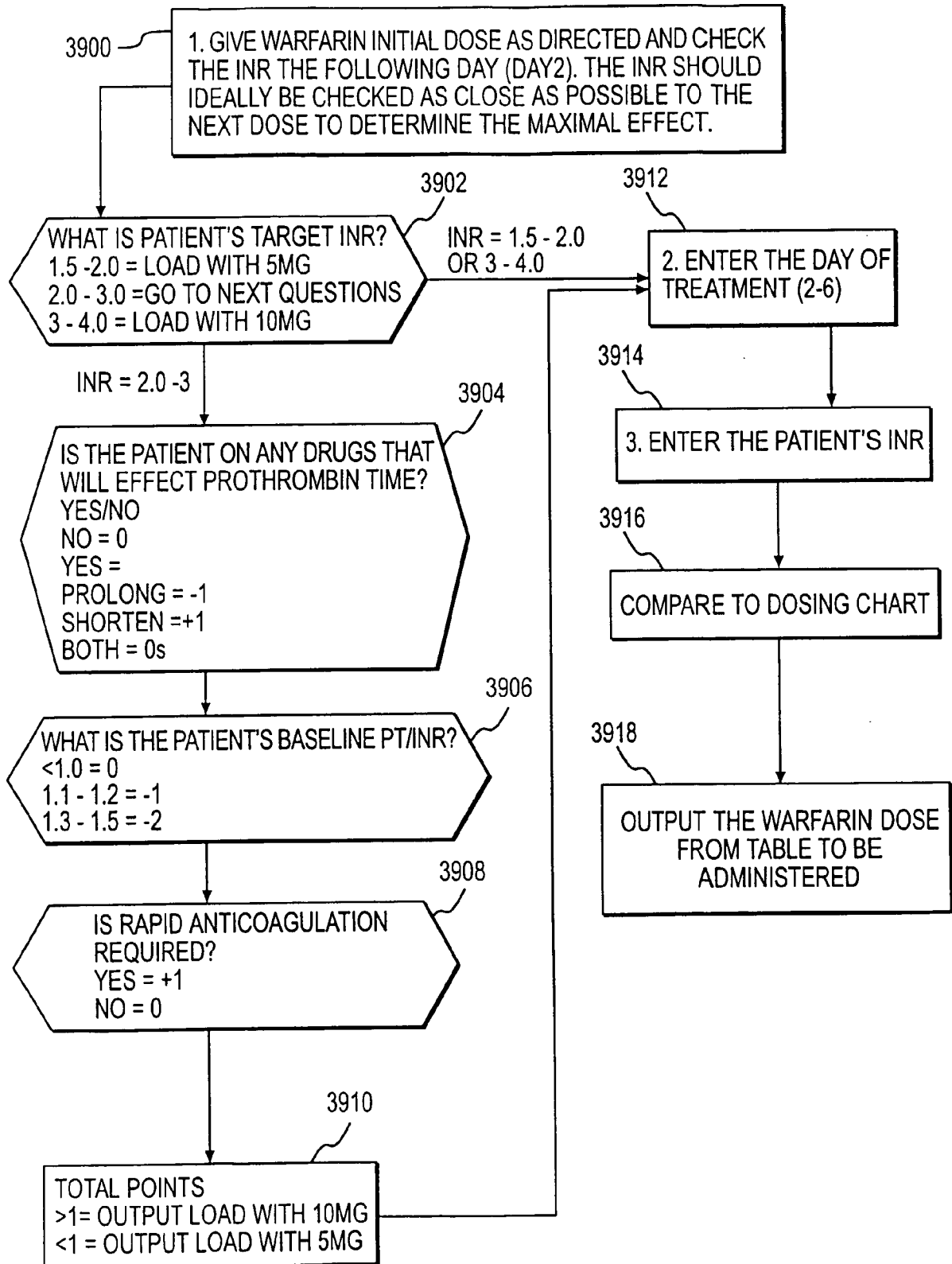
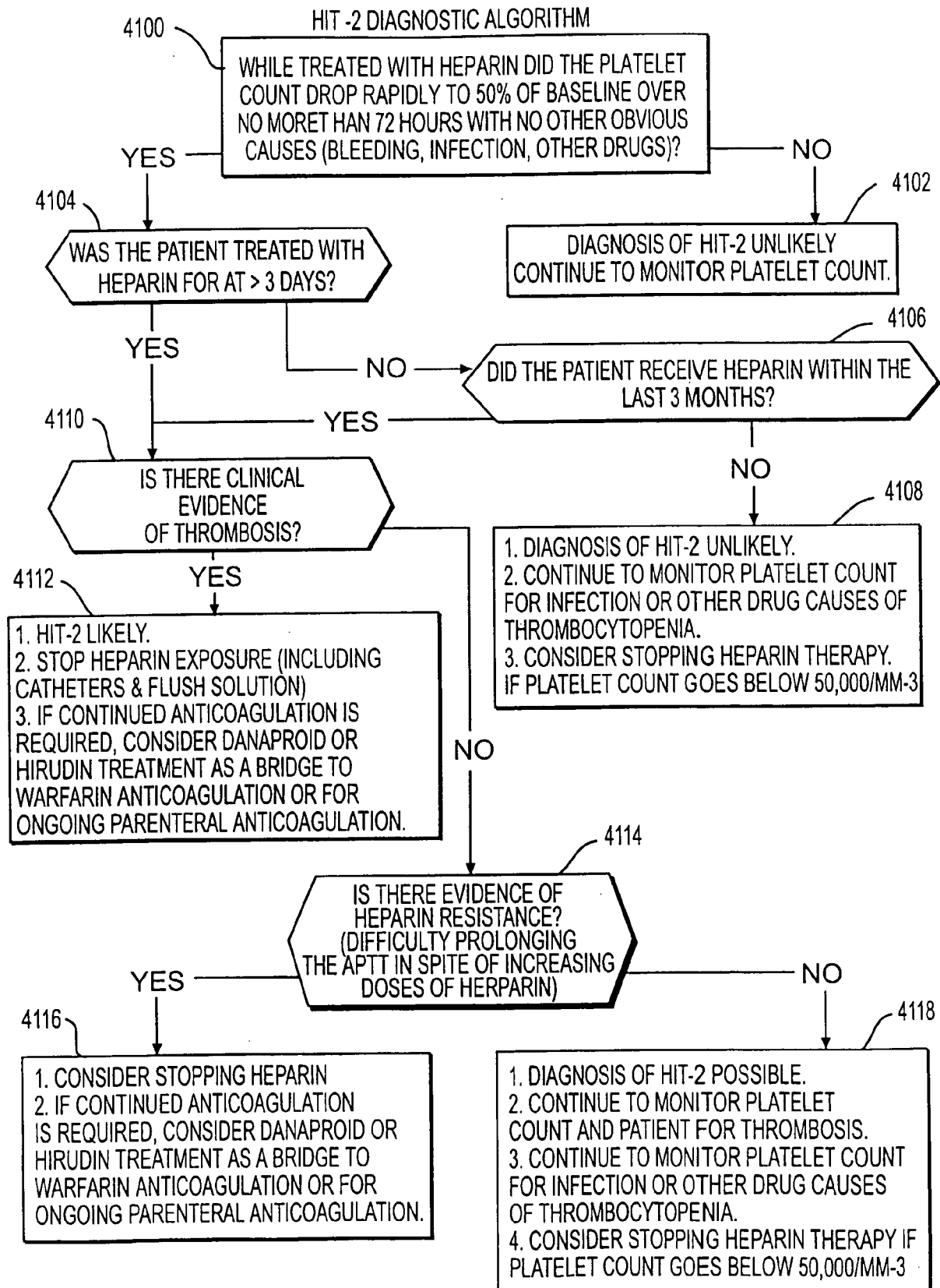
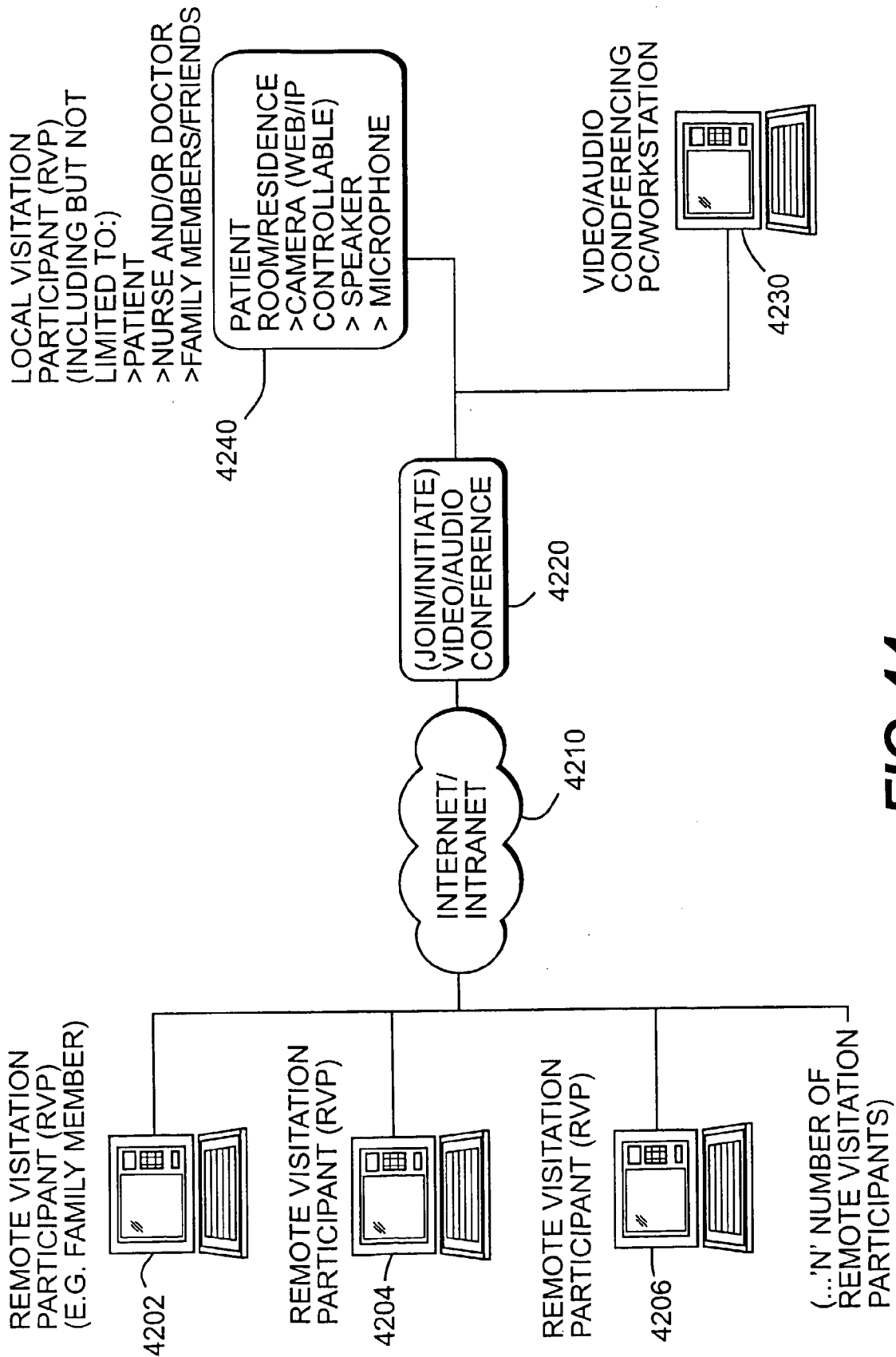


FIG. 42

**FIG.43**



**FIG.44**